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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

BULLETINS

Nos. 342-345

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

133289

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 342

RESULTS

OF

SPIRIT LEVELING IN CALIFORNIA

1896 TO 1907, INCLUSIVE

BY

S. S. GANNETT AND D. H. BALDWIN

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

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RESULTS OF SPIRIT LEVELING IN CALIFORNIA FOR THE YEARS 1896 TO 1907, INCLUSIVE.

By S. S. GANNETT and D. H. BALDWIN.

INTRODUCTION.

All results of spirit leveling in California for the years 1896 to May, 1907, including that previously reported upon in Appendixes to Reports of the Director of the United States Geological Survey and in Bulletin No. 185 are herein given, readjusted and rearranged by quadrangles. Descriptions and elevations of bench marks are given for 42 counties, furnishing vertical control for one-third of the State. The leveling since 1903 in the Sacramento Valley, in Colusa, Contra Costa, Glenn, Sacramento, Solano, San Joaquin, Tehama, and Yolo counties, was done in cooperation with the State.

The field work was done under the direction of Mr. R. U. Goode, geographer, 1896 to June, 1903, and under Mr. E. M. Douglas, geographer, since that date. The work of 1904 to 1907, inclusive, was mostly done under the immediate supervision of Mr. R. B. Marshall, geographer, chief of section. Credit is given in the heading of each list to the various topographers and levelmen directly in charge.

The office work of adjustment was done principally by Messrs. L. C. Fletcher and D. H. Baldwin, topographers, under the supervision of Mr. S. S. Gannett, geographer in charge of the triangulation and computing section.

The lists are separated into two classes, precise and primary, distinguishing the degree of refinement in the method of leveling employed. The elevations under precise leveling were determined by lines run either in both forward and backward directions or by simultaneous double-rodded lines, a high-grade level and rated rods being used and special precautions being taken in observation and reduction to correct error and make the results continuously good; elevations under primary leveling were determined mostly by single lines run with prism or with Y level in circuits required to close within a limiting error represented in feet by the formula 0.05 $\sqrt{D}$ in which D is the length of circuit in miles. The lines of precise leveling in this State have been run under different restrictions, and are therefore of slightly different grades of accuracy. The lines Barstow to Mohave and Mohave to Laws and Oasis were run under the same method as now used by the United States Coast and Geodetic Survey except that on the former yard rods instead of metric rods were used and the computation was made in feet from three thread readings, and on the latter a different type of instrument was used and the limit of error and lengths of sections were greater. The limits on these lines are expressed respectively by 0.017 $\sqrt{D}$ (equivalent to United States Coast and Geodetic Survey limit) and 0.03 $\sqrt{D}$ in which D is distance between bench marks in miles. The lines from Benicia to Pacoima and to the Oregon line were run as simultaneous double-rodded lines with rod correction made for normal temperature and the partial divergence required to keep within a limit in feet represented by the formula 0.03 $\sqrt{2D}$ or 0.04 $\sqrt{D}$ in which D is distance between bench marks in miles.

The various groups of level lines are all based upon mean sea level, but between certain lists there are outstanding errors of closure which can not be adjusted satisfactorily until more field work is done.

The bench marks described in the following lists are of three general forms. First, a circular bronze or aluminum tablet 3½ inches in diameter and one-fourth inch thick, appropriately lettered, having a 3-inch stem cemented into a drill hole, generally in the vertical walls of public buildings, bridge abutments, or other substantial masonry structures. The second form, employed where masonry or rock is not accessible, consists of a hollow wrought-iron post 3½ inches in outer diameter, 4 feet long after being split and expanded at bottom to 10 inches, so as to prevent both the easy subsidence of the post and its being maliciously pulled out of the ground. The iron is heavily coated with asphalt, and over the top of the post is riveted a bronze tablet similar to that described above. The third form (used in 1896 and 1897) was a copper bolt 4 inches long and 1 inch in diameter fastened into masonry or solid rock by driving it on a brass wedge in the bottom of a vertical hole, so that the top of the bolt was horizontal and thus formed a bench mark.

Numbers stamped upon the bench marks described in the following lists represent the elevations, to the nearest foot above mean sea level, as determined by unadjusted levels in the field. In some cases the finally accepted elevations as printed herein, resulting from the adjustments necessary to close circuits and from reduction to mean sea level through readjustment of the precise-level net, differ from the bench-mark numbers by several feet. This method of numbering bench marks has been adopted where many levelers are working in the same area at the same time, as less liable to lead to confusion in identification of bench marks, and at the same time giving an approximate statement of elevation. Serial numbering is employed on special lines. It is assumed that engineers and others finding these bench marks so stamped in the field will communicate with the Director of the United States Geological Survey in order to obtain the accepted elevation to hundredths or thousandths of a foot.

Any person finding bench marks in the following lists mutilated or destroyed will confer a favor by notifying the Director, United States Geological Survey, Washington, D. C.

PRECISE LEVELING.

BARSTOW, KRAMER, MOHAVE, AND PALMDALE QUADRANGLES.

KERN AND SAN BERNARDINO COUNTIES.

The elevations in the following list are the adjusted result of a line of precise leveling run between Barstow and Mohave in 1906 by Mr. L. F. Biggs, levelman. The elevation accepted at Barstow is that determined by unadjusted precise leveling of 1906 by the United States Coast and Geodetic Survey from San Diego, and the elevation at Mohave is that determined by an adjustment made in January, 1907, taking account of this line, the precise line of 1901 and 1902 from Benicia to Pacoima, to which it was found necessary to apply an additional rod correction of 0.0006 foot, per vertical foot (increasing differences of elevation), on account of rerunning, and the double-rodded primary line between Pacoima and a bench mark at San Bernardino recovered by the Coast and Geodetic Survey line. The adjustment lowers the elevation at Mohave by this line 0.361 foot with respect to Barstow, this discrepancy being distributed over the total distance of 70 miles.

The instruments used were two self-reading rods 3½ yards in length, graduated to yards and hundredths and reading by estimation to thousandths, and a precise level of the Coast and Geodetic Survey type.

The method adopted was that now used by the United States Coast and Geodetic Survey. The line was broken by temporary bench marks into sections about 1 mile in length; each section was leveled independently in both forward and backward directions, and on all sections upon which the forward and backward measures computed in feet differed by more than $0.017 \sqrt{D}$ (in which D is the distance in miles between bench marks), forward and backward measures were repeated until a pair run in opposite directions fell within the limit.

BARSTOW, ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO MOHAVE.

BARSTOW QUADRANGLE.

	Feet.
Barstow, 705 feet west of station, 2½ telegraph poles east of milepost 747, 115 feet north of track, on land of Charles O'Donnell, in fence corner; bottom of a square hole in top of cement post projecting 6 inches above ground (established by U. S. Coast and Geodetic Survey)	2,101.707
Barstow, on railroad right of way, at south end of viaduct over track, northwest corner of west concrete foundation; red metal U. S. C. & G. S. tablet	2,111.117
Barstow, 2 miles west of, 16 feet north of milepost 749; iron post	2,139.368
Barstow, 5 miles west of, 6 feet north of milepost 752; iron post	2,173.522
Barstow, 8 miles west of, 6 feet north of milepost 755; iron post	2,174.841
Barstow, 11 miles west of, 6 feet north of milepost 758; iron post	2,178.755
Barstow, 14 miles west of, 6 feet north of milepost 761; iron post	2,185.492
Kramer, 16 miles east of, 6 feet north of milepost 764; iron post	2,246.929
Hiawatha, in front of station; top of rail	2,281.1
Kramer, 13 miles east of, 6 feet north of milepost 767; iron post	2,280.739
Kramer, 10 miles east of, 6 feet north of milepost 770; iron post	2,367.936
Kramer, 7 miles east of, 6 feet north of milepost 773; iron post	2,422.518
Kramer, 4 miles east of, 6 feet north of milepost 776; iron post	2,455.767

KRAMER QUADRANGLE.

Kramer, 1 mile east of, 6 feet north of milepost 779; iron post	2,482.885
Kramer, 2 miles west of, 6 feet north of milepost 782; iron post	2,509.442
Kramer, 5 miles west of, 6 feet north of milepost 785; iron post	2,435.951
Kramer, 8 miles west of, 6 feet north of milepost 788; iron post	2,374.398
Rich, in front of station; top of rail	2,347.0
Rodriguez, 7 miles east of, 6 feet north of milepost 791; iron post	2,280.769
Rodriguez, 4 miles east of, 6 feet north of milepost 794; iron post	2,275.240
Rodriguez, 1 mile east of, 6 feet north of milepost 797; iron post	2,272.326
Rodriguez, in front of station; top of rail	2,286.248
Rodriguez, 2 miles northwest of, 6 feet north of milepost 800; iron post	2,321.563
Rodriguez, 5 miles northwest of, 6 feet north of milepost 803; iron post	2,370.300

PALMDALE QUADRANGLE.

Rodriguez, 8 mlies northwest of, 6 feet north of milepost 806; iron post	2,420.435
Bissell, in front of station; top of rail	2,450.7
Mohave, 9 miles southeast of, 6 feet north of milepost 809; iron post	2,462.194

MOHAVE QUADRANGLE.

Mohave, 6 miles southeast of, 4 feet north of milepost 812; iron post	2,541.179
Mohave, 3 miles southeast of, 10 feet north of milepost 815; iron post	2,618.240
Mohave, 0.4 mile south of, 25 feet north of milepost 382, west of track; iron post	2,733.451

BALLARAT, BISHOP, LIDA, MOHAVE, MOUNT WHITNEY, PILOT PEAK, AND OLANCHA QUADRANGLES.

KERN AND INYO COUNTIES.

The following elevations are the results of a spur line of precise levels run in the spring of 1905 by Mr. R. A. Farmer, topographer, northward from Mohave along stage road to Keeler, thence along the Carson and Colorado Railway to Laws, and from Alvord northeast to the State line near Oasis.

The instruments used were a Buff & Berger level and two self-reading rods, 3.1 meters in length, graduated to centimeters and reading by estimation to millimeters.

The method adopted was a modification of that now used by the Coast and Geodetic Survey. The line was broken by temporary bench marks into sections 2 to 3 kilometers in length; each section was leveled independently in the forward and backward directions, and on all sections upon which the forward and backward measures differed by more than 8 $\sqrt{K}$ millimeters (which is twice the U. S. C. & G. S. limit generally used), in which K is the distances between adjacent bench marks in kilometers, both the forward and backward measures were repeated until such measures fell within this limit.

The initial bench mark is an iron post stamped "2732 B," 0.4 mile south of Mohave, 25 feet north of milepost 382, the elevation of which is now accepted as 2,733.451 feet above mean sea level.

MOHAVE, NORTHWARD ALONG STAGE ROAD, TO KEELER.

MOHAVE QUADRANGLE.

	Feet.
Mohave, 0.4 mile south of, 25 feet north of milepost 382, west of track; iron post stamped "2732 B"	2,733.451
Mohave, 3.5 miles northeast of, 10 feet south of road; iron post stamped "2955 B"	2,957.090
Mohave-Tehachapi-Randsburg signboard, 1.1 miles northeast of, 10 feet south of road; iron post stamped "2745 B"	2,746.614
Mohave-Tehachapi-Randsburg signboard, 4.3 miles northeast of, 10 feet east of road; iron post stamped "2588 B"	2,589.830
Mohave-Tehachapi-Randsburg signboard, 7.3 miles northeast of, 10 feet east of road; iron post stamped "2419 B".	2,421.143
Eighteenmile station, 1.8 miles south of, 20 feet east of road, 50 feet east of Copper Mining mail box; iron post stamped "2152 B"	2,154.019
Eighteenmile station, 1.1 miles north of, 10 feet east of road; iron post stamped "2108 B"	2,110.231
Eighteenmile station, 4.2 miles north of, 10 feet west of road; iron post stamped "2123 B"	2,125.038
Ricardo (formerly Red Rock) post-office, 0.7 mile northwest of, 20 feet north of road; iron post stamped "2442 B"	2,443.624
Ricardo post-office, 3.8 miles northwest of, 40 feet west of road; iron post stamped "2902 B"	2,904.200
Ricardo post-office, 6,4 miles northwest of, 50 feet west of road, at Summit of Red Rock Canyon; iron post stamped "3520 B"	3,522.165
Dixie stage station, 1.3 miles southwest of, 10 feet west of road; iron post stamped "3281 B"	3,282.964

PILOT PEAK QUADRANGLE.

	Feet.
Dixie stage station, 2 miles northeast of, 10 feet east of road; iron post stamped "3172 B"	3,174.253
Dixie station, 5.3 miles northeast of, 10 feet west of road; iron post stamped "3290 B"	3,292.257
Freeman, 400 feet south of, 20 feet west of road on hillside south side of Walker Canyon; iron post stamped "3379 B"	3,381.335
Freeman, 3.2 miles northeast of, 30 feet east of road; iron post stamped "3110 B"	3,111.837
Indian Wells, 300 feet north of, 20 feet west of road; iron post stamped "B"	2,740.161
Indian Wells, 3.1 miles north of, 10 feet east of road; iron post stamped "B"	2,698.352
Indian Wells, 5.9 miles north of, 30 feet west of road; iron post	2,599.124
Indian Wells, 9.2 miles north of, 40 feet east of road; iron post	2,486.654
Little Lake, 8.8 miles south of, 40 feet west of road, at summit of granite bowlder; aluminum tablet	2,573.550
Little Lake, 4.6 miles south of, 70 feet east of road, at summit of granite bowlder; aluminum tablet	2,818.259
Little Lake, 1.2 miles south of, 10 feet east of road, summit of black bowlder; aluminum tablet	2,947.774
Little Lake, 1.7 miles north of, 50 feet west of road, at summit of granite bowlder; aluminum tablet	3,329.511
Little Lake, 4.9 miles north of, 50 feet east of dry lake bed, 40 feet east of road, in summit of lava bowlder; aluminum tablet	3,333.529

BALLARAT QUADRANGLE.

Little Lake, 8.1 miles north of, 40 feet east of road; iron post	3,369.852
Little Lake, 10.9 miles north of, 25 feet west of road; iron post	3,444.171
Hawai Meadows, 3.4 miles south of, 80 feet east of road; iron post	3,641.821
Hawai Meadows, 720 feet north of house, 35 feet west of road; iron post	3,734.101
Hawai Meadows, 3.1 miles north of, 100 feet west of road on hillside, at summit of granite bowlder; aluminum tablet	3,736.969
Olancha, 2.2 miles south of, 20 feet east of road; iron post	3,716.886

OLANCHA QUADRANGLE.

Olancha, 2 feet east of post-office porch; iron post	3,649.391

BALLARAT QUADRANGLE.

Olancha, 3.2 miles northeast of, 20 feet southeast of road; iron post	3,619.361
Olancha, 6.4 miles northeast of, 50 feet northwest of road; iron post	3,628.710
Olancha, 9.4 miles northeast of, 20 feet northwest of road; iron post	3,612.718
Keeler, 6.9 miles southwest of, 30 feet north of road; iron post	3,618.405
Keeler, 3.4 miles southeast of, 25 feet east of road; iron post	3,631.009
Keeler, at southeast corner of post-office; iron post	3,610.307
Keeler, in front of station; top of east rail	3,600.9
Keeler, 0.5 mile northwest of, 10 feet from road, marble rock cut 1 foot square, 3 feet high, marking azimuth station; top of copper plate at intersection of cross lines	3,599.489

	Feet.
Keeler, 2.1 miles northwest of, 150 feet south of the Soda Works pipe line, 400 feet east of Owens Lake; iron post	3,570.235
Owens Lake, 200 feet southeast of Soda Company's pipe; surface of water, March 30, 1905	3,568.7

KEELER, ALONG CARSON AND COLORADO RAILWAY, TO LAWS.

BALLARAT QUADRANGLE.

Keeler, 3 miles north of, 8 feet north of telegraph pole opposite milepost 290; iron post	3,608.157
Inyo marble quarry, 1 mile north of, 25 feet north of milepost 287; iron post	3,674.699
Inyo quarry, 4 miles north of, 200 feet north of milepost 284; iron post	3,671.961

MOUNT WHITNEY QUADRANGLE.

Mount Whitney station, 0.5 mile south of, 100 feet south of milepost 281; iron post	3,681.507
Mount Whitney station, in front of; top of east rail	3,688.809
Mount Whitney station, 2.5 miles north of, 3 feet east of track, opposite milepost 278; iron post	3,689.764
Mount Whitney station, 5.5 miles north of, 10 feet south of milepost 275; iron post	3,717.763
Francis, in front of station; top of east rail	3,724.257
Francis, 100 feet northeast of station, east of track; iron post	3,723.232
Francis, 3 miles north of station, at milepost 269; iron post	3,738.544
Citrus, in front of station; top of east rail	3,765.3
Citrus, in front of station; iron post	3,766.400
Citrus, 3 miles north of station, at milepost 264; iron post	3,764.016
Citrus, 6 miles north of station; iron post	3,785.690
Aberdeen, 5 miles south of, 20 feet north of milepost 258; iron post	3,814.559
Aberdeen, 2 miles south of, at milepost 255; iron post	3,831.595

BISHOP QUADRANGLE.

Aberdeen, 1 mile north of, at milepost 252; iron post	3,850.144
Aberdeen, 4 miles north of, 60 feet south of milepost 249; iron post	3,859.267
Alvord, 6.5 miles south of, at milepost 246; iron post	3,881.276
Alvord, 3.5 miles south of, at milepost 243; iron post	3,897.130
Alvord, in front of station; iron post	3,930.130
Alvord, in front of station; top of rail	3,929.6
Alvord, 2.5 miles north of, 120 feet south of milepost 237, west of track; iron post	3,952.144
Alvord, 5.5 miles north of, 100 feet north of milepost 234; iron post	3,981.047
Alvord, 8.5 miles north of, at milepost 231; iron post	4,007.490
Alvord, 10.5 miles north of, 150 feet south of milepost 229; iron post	4,035.106
Laws, 2.5 miles south of, 2 feet south of milepost 226; iron post	4,064.895
Laws, in front of station; top of east rail	4,112.7
Laws, in front of station; iron post stamped "B 4116, 1905"	4,114.583
Laws, 2.5 miles north of, at milepost 221; iron post	4,142.000
Laws, 5.5 miles north of, milepost 218; iron post	4,210.192

ALVORD, NORTHEAST ALONG COUNTY ROADS, TO OASIS AND STATE LINE.

BISHOP QUADRANGLE.

	Feet.
Alvord, 2.9 miles northeast of, 10 feet north of road, summit of rock 2.5 by 2.5 by 1.5 feet; aluminum tablet	4,502.388
Alvord, 6.4 miles northeast of, 300 feet southeast of toll house, summit of rock 3 by 3 by 2 feet, aluminum tablet	5,971.350
Alvord, 10.7 miles northeast of, 20 feet south of road, on summit near cedar tree; iron post	7,276.225
Payson cabin, 0.5 mile east of, 40 feet east of road; iron post	6,556.830
Road to Payson's ranch, 10 feet south of road forks; iron post	5,519.064
Payson's ranch, 5 miles east of, 20 feet north of road; iron post	5,108.922
Gilbert ranch, 0.7 mile northwest of, 20 feet south of road; iron post	5,209.692
Gilbert ranch, 1.5 miles northeast of, 30 feet north of road; iron post	5,314.341

LIDA QUADRANGLE.

Piper ranch, first summit west of; iron post	6,371.105
Oasis, 2.5 miles southwest of, at road forks; iron post	5,299.775
Oasis, northeast corner of post-office wall; bronze tablet stamped "5106 C. C." (old value, 5.106.101.—Appendix to 19th Ann. Report)	5,031.226
Oasis, 3 miles southeast of, 30 feet north of road, 0.25 mile east of forks of road; iron post	5,080.887

BAKERSFIELD SPECIAL, CARQUINEZ, DAVISVILLE, FAIROAKS, FERNANDO, SANTA SUSANA, TUJUNGA, VACAVILLE, AND WOODLAND 15′ QUADRANGLES; BAKERSFIELD, CALIENTE, FAMOSO, FRESNO, HANFORD, LODI, LOS BANOS, MADERA, MERCED, MOHAVE, NAPA, OAKDALE, PALMDALE, SACRAMENTO, STOCKTON, AND VISALIA 30′ QUADRANGLES.

FRESNO, KERN, KINGS, LOS ANGELES, MADERA, MERCED, SACRAMENTO, SAN JOAQUIN, SOLANO, STANISLAUS, TULARE, AND YOLO COUNTIES.

The elevations in the following list are based upon a bench mark of the United States Coast and Geodetic Survey, described as the upper surface of a ⅝-inch iron bolt driven in a hole drilled horizontally in the southwestern face of a sandstone rock smoothed a foot square, at the top of a ledge near high-water mark at Benicia Arsenal, just south of the railroad and east of the arsenal wharf. The elevation of the bench mark was accepted as 5.980 feet above mean sea level.

The line was originally checked and adjusted by connecting with a bench mark at Pacoima, previously established from the tidal bench mark at San Pedro, and published in Appendix to the Nineteenth Annual Report, page 387, the closure error being —0.243 foot in 523 miles; but the rerunning of a portion of this line near Mohave in 1906 by precise leveling showed that the rods that were used on this line had apparently lengthened 0.0006 foot per vertical foot over their original rating, and the section Tipton to Pacoima has been corrected for this error and adjusted additionally to make a total correction to the previous adjusted height at Mohave of +2 feet and of +0.7 foot at Pacoima. The correction at Pacoima is derived through an unadjusted double-rodded primary line of 1896, by H. S. Crowe, from San Bernardino, at which place the elevation determined in 1906 by precise leveling of the Coast and Geodetic Survey from Point Loma (near San Diego) is accepted, and the old elevation of the tidal bench mark at San Pedro disregarded. The Coast and Geodetic Survey gage height at Santa Monica, formerly disregarded but now accepted, makes correction to Crowe's double line at that place +0.886 foot. The elevation now adopted at Mohave is 0.36 foot less than that determined from San Bernardino by precise levels of 1906 by the Coast and Geodetic Survey to Barstow, and by United States Geological Survey thence to Mohave, it is 0.25 greater than that brought from San Bernardino via Pacoima using Semper's line corrected for the additional rod error, and 0.52 foot greater than by using Semper's corrected line from Benicia.

The leveling was done in 1901 and 1902 by Mr. C. H. Semper, levelman in charge, using a Buff & Berger precise level and the double simultaneous method.

BENICIA, VIA SOUTHERN PACIFIC RAILROAD, TO SACRAMENTO.

CARQUINEZ 15′ (NAPA 30′) QUADRANGLE.

	Feet.
Goodyear, in front of station; top of rail	7.9
Oluta, in front of station; top of rail	5.9
Teal, in front of station; top of rail	5.6
Fairfield, at left of main entrance to court-house. 7.5 feet below bottom of stone ledge to first window of auditor's office; bronze tablet stamped "15"[a]	15.170

VACAVILLE QUADRANGLE.

Suisun, 3.9 miles north of, 25 feet east of track, 3 feet south of milepost 53; iron post stamped "47 B"	46.833
Vanden, in front of station; top of rail	73.4
Canon, 12 feet south of station, 12 feet west of track; iron post stamped "89 B"	88.650
Canon, in front of station; top of rail	87.8
Canon, 2.6 miles north of, west side of track, 8 feet south of milepost 59; iron post stamped "80 B"	80.291
Elmira, in front of station; top of rail	75.0
Elmira, 1.7 miles north of, 33 feet east of track, 2 feet west of milepost 62; iron post stamped "62 B"	62.282
Batavia, 2 feet from north end of station, 27 feet east of track; iron post stamped "62 B"	61.758
Dixon, 700 feet south of station, west side of track, at highway crossing, south side of road, at corner of fence; iron post stamped "61 B"	61.295

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[a] This bench mark was originally established in 1896, the elevation as then determined being 15.151 (See Appendix to 18th Ann. Report, 1896–7, p. 414).

	Feet.
Dixon, in front of station; top of rail	62.9
Dixon, 2.4 miles north of, east side of track, 3 feet from milepost 71; iron post stamped "58 B"	57.618
Tremont, in front of station; top of rail	58.9

WOODLAND QUADRANGLE.

Tremont, 1.3 miles north of, east side of track, 5 feet from milepost 74; iron post stamped "49 B"	48.890
Davisville, in front of Davis station; top of rail	47.4
Davisville, 0.4 mile east of, south side of track, 5 feet from milepost 77; iron post stamped "42 B"	42.095
Davisville, 3.3 miles east of, south side of track, 18 feet south of milepost 80, on fence line; iron post stamped "28 B"	27.644
Swingle, in front of station; top of rail	28.1
Webster, in front of station; top of rail	22.2
Webster, 1.5 miles east of, south side of track, 5 feet west of milepost 83; iron post stamped "14 B"	14.060
Milepost 86, 4 feet north by 15 feet east of, south side of track; iron post stamped "17 B"	17.339
Broderick, in front of station; top of rail	26.3
Broderick, at Third street crossing; top of rail	29.3
Sacramento, in front of station; top of rail	29.6

SACRAMENTO, VIA SOUTHERN PACIFIC RAILROAD, TO STOCKTON.

DAVISVILLE QUADRANGLE.

Sacramento, at foot of L street, south end of steamer shed; 34 foot mark of the United States Weather Bureau gage (determined by R. A. Farmer, 1905)	33.524

FAIROAKS 15′ (SACRAMENTO 30′) QUADRANGLE.

Sacramento, 300 feet east of Capitol, in top of surface of meridian stone; aluminum tablet stamped "21 B" (elevation by Coast and Geodetic Survey is 2.876 feet higher)	20.865
Sacramento, at Thirteenth street crossing; top of rail	21.3
Sacramento, at Twenty-fifth street crossing; top of rail	24.0
Brighton, in front of station; top of rail	42.4
Brighton, 200 feet south of station, 20 feet west of track, at telegraph pole; iron post stamped "41 B"	41.042
Brighton, 3.2 miles south of, 6 feet south of milepost 131, east side of track; iron post stamped "36 B"	35.741

LODI 30′ QUADRANGLE.

Florin, 150 feet north of station, at crossing; top of rail	39.3
Milepost 127, 4 feet south of, east side of track, at crossing; iron post stamped "37 B"	36.740
Elk Grove, on Main street, 30 feet west of track, 4 feet south of street line; iron post stamped "49 B"	49.289
Elk Grove, in front of station; top of rail	49.4

	Feet.
McConnells, 50 feet north of station, 50 feet east of track; iron post stamped "46 B"	46.390
Arno, 50 feet south of station, west side of track, at fence line; iron post stamped "35 B"	35.058
Arno, in front of station; top of rail	36.9
Milepost 115, 10 feet south of, east side of track; iron post stamped "42 B"	41.880
Galt, in front of station; top of rail	46.2
Galt, on line with north margin of station, 30 feet west of track; iron post stamped "46 B"	45.576
Forest Lake, in front of station; top of rail	48.2
Milepost 109, 15 feet north of, east side of track at crossing; iron post stamped "48 B"	48.296
Acampo, in front of station; top of rail	55.6
Acampo, 1 mile south of, east side of track at crossing, north margin of road; iron post stamped "53 B"	52.625
Lodi, in front of station; top of rail	50.7
Lodi, 1.5 miles south of, east side of track, at crossing, north side of road at angle of fence; iron post stamped "45 B"	45.286
Milepost 100, 5 feet south of, east side of track at fence line; iron post stamped "37 B"	37.430
Milepost 97, 15 feet north of, east side of track, at fence line; iron post stamped "28 B"	28.111

STOCKTON QUADRANGLE.

Milepost 94, 8 feet north of, east side of track, on fence line; iron post stamped "20 B"	20.075

STOCKTON, VIA SOUTHERN PACIFIC RAILROAD, TO FRESNO.

STOCKTON QUADRANGLE.

Stockton, at Park street crossing; top of rail	18.6
Stockton, west door of north entrance of San Joaquin County courthouse, in angle of wall; bronze tablet stamped "18 B"[a]	17.953
Stockton, in front of station; top of rail	18.8
Stockton, at Sacramento street crossing; top of rail	22.0
Stockton, 0.6 mile south of, at crossing of Santa Fe railroad; top of rail	21.7
Milepost 88, 8 feet south of, east side of track, at fence line; iron post stamped "15 B"	14.679
French Camp, in front of station; top of rail	19.4
Milepost 85, 200 feet east of, east side of track, at road crossing, at fence line; iron post stamped "19 B"	18.971
Lathrop, 250 feet north of station, at northwest corner of railroad park, on margin of road; iron post stamped "20 B"	19.938
Lathrop, in front of station; top of rail	21.6
Monteca, 25 feet south of station, 20 feet west of milepost 98, at fence line; iron post stamped "36 B"	35.831
Monteca, 2.9 miles south of, 20 feet west of milepost 10, west side of track, at fence line; iron post stamped "45 B"	44.998

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[a] This bench mark was originally established in 1896, the elevation as then determined being 17.461 (see Appendix to 18th Ann. Report, 1896-7, p. 416).

	Feet.
Milepost 104, 50 feet north of, west side of track, at fence line; iron post stamped "61 B"	61.073
Ripon, crossing at station; top of rail	67.5
Ripon, 2.3 miles south of, opposite milepost 107, east side of track, at fence line; iron post stamped "67 B"	66.592
Salida, 2.6 miles south of, opposite milepost 110, east side of track, at fence line; iron post stamped "78 B"	77.567
Milepost 113, opposite, east side of track, at fence line; iron post stamped "82 B"	82.117
Modesto, in front of station; top of rail	86.1
Modesto, in southwest corner of court-house; bronze tablet stamped "91 B"	91.329

OAKDALE QUADRANGLE.

Modesto, 1.6 miles south of, 10 feet south of milepost 116, west side of track, at fence line; iron post stamped "86 B"	86.184
Ceres, in front of station; top of rail	88.4
Esmar, in front of station; top of rail	93.4
Keyes, opposite milepost 122, 75 feet east of side track, on west margin of highway; iron post stamped "92 B"	92.408
Keyes, 2.9 miles south of, opposite milepost 125, east side of track, at fence line; iron post stamped "100 B"	100.214
Turlock, in front of station; top of rail	101.1

LOS BANOS QUADRANGLE.

Turlock, 0.6 mile south of, opposite milepost 128, on east margin of highway; iron post stamped "103 B"	102.952
Turlock, 3.6 miles south of, 5 feet north of milepost 131, west side of track; iron post stamped "111 B"	111.299
Milepost 134, 27 feet south of; iron post stamped "116 B"	116.456
Milepost 137, 5 feet north of, west side of track, at fence line; iron post stamped "129 B"	128.818
Livingston, in front of station; top of rail	130.6
Livingston, 2.5 miles south of, opposite milepost 140, east side of track, at margin of highway; iron post stamped "142 B"	141.839
Arena, in front of station; top of rail	140.5
Arena, 2.9 miles south of, opposite mile post 143, east side of track, at fence line; iron post stamped "154 B"	153.877
Atwater, in front of station; top of rail	147.7
Buhach, 60 feet north of station, opposite milepost 146; iron post stamped "153 B"	152.679
Buhach, in front of station; top of rail	155.4
Milepost 149, opposite, east side of track, at margin of road; iron post stamped "154 B"	154.374

MERCED QUADRANGLE.

Merced, in southeast corner of county court-house; aluminum tablet stamped "171 B"	171.118
Merced, 3.2 miles south of, opposite milepost 155, east side of track at margin of highway; iron post stamped "178 B"	178.505

	Feet.
Milepost 158, opposite, east side of track, at margin of highway; iron post stamped "187 B"	187.587
Milepost 161, opposite east side of track, at margin of highway, iron post stamped "198 B"	198.474
Athlone, in front of station; top of rail	204.0
Athlone, 2.5 miles south of, opposite milepost 164, east side of track, at margin of highway; iron post stamped "217 B"	217.392
Milepost 157, 150 feet south of, east side of track, at margin of highway; iron post stamped "233 B"	232.731
Minturn, in front of station; top of rail	238.6
Minturn, 1.9 miles south of, opposite milepost 170, east side of track, at margin of highway; iron post stamped "241 B"	240.597
Milepost 173, opposite, east side of track, at margin of highway; iron post stamped "247 B"	246.703
Milepost 176, opposite, east side of track, at margin of highway; iron post stamped "249 B"	249.281
Berenda, in front of station; top of rail	250.3
Berenda, 1.3 miles south of, 18 feet south of milepost 179, west of track, at margin of highway; iron post stamped "248 B"	248.264
Milepost 182, 15 feet south of, west of side track, at margin of highway; iron post stamped "270 B"	270.432

MADERA QUADRANGLE.

Madera, in front of station; top of rail	272.0
Madera, in front face of northeast corner of county court-house; aluminum tablet stamped "274 B"	274.030
Borden, in front of station; top of rail	269.6
Borden, 1,000 feet south of station, 100 feet south of milepost 188, at corner of fence, west side of track; iron post stamped "269 B"	269.464

FRESNO QUADRANGLE.

Milepost 191, 8 feet south of, west side of track, at margin of highway; iron post stamped "273 B"	273.972
Milepost 194, 6 feet south of, west side of track, at margin of highway; iron post stamped "284 B"	284.571
Milepost 197, 300 feet south of, 55 feet east of track, at crossing; iron post stamped "300 B"	300.150
Milepost 200, 10 feet south of, west side of track, at margin of highway; iron post stamped "297 B"	296.738
Milepost 203, 225 feet south of, west side of track, at margin of highway; iron post stamped "296 B"	295.910
Fresno, in west face of passenger station, south of door to gentlemen's waiting room; aluminum tablet stamped "290 B"	289.983

FRESNO, VIA SOUTHERN PACIFIC RAILROAD, TO BAKERSFIELD.

FRESNO QUADRANGLE.

Fresno, opposite south end of passenger station; top of rail of main line	287.1
Fresno, 1 mile south of, at Cherry-avenue crossing; top of rail	286.3

	Feet.
Fresno, 2.3 miles south of, 14 feet south of milepost 209, west side of track, at margin of highway; iron post stamped "286 B"	286.421
Crossing of Santa Fe and Southern Pacific railroads; top of rail	290.3
Malaga, in front of station, top of rail	293.2
Malaga, 0.4 mile south of, 15 feet south of milepost 212, west side of track, at margin of highway; iron post stamped "297 B"	297.037
Malaga, 3.5 miles south of, 10 feet south of milepost 215, east side of track, at margin of highway; iron post stamped "300 B"	300.465
Fowler, in front of station; top of rail	304.1
Fowler, 1.7 miles south of, 12 feet south of milepost 218, west side of track, at margin of highway; iron post stamped "304 B"	303.871
Selma, 0.8 mile north of, 11 feet south of milepost 221, west side of track, at margin of highway; iron post stamped "310 B"	310.368
Selma, in front of station; top of rail	305.8
Selma, 2.2 miles south of, 8 feet south of milepost 224, west side of track, at margin of highway; iron post stamped "305 B"	304.755
Kingsburg, in front of station; top of rail	296.6
Kingsburg, 0.3 mile south of, opposite milepost 227, west side of track, at margin of highway; iron post stamped "295 B"	294.754

HANFORD QUADRANGLE.

Kingsburg, 3 miles south of, 8 feet south of milepost 230, west side of track, at margin of highway; iron post stamped "295 B"	295.119

VISALIA QUADRANGLE.

Traver, in front of station; top of rail	285.3
Traver, 0.5 mile south of, 19 feet south of milepost 233, west side of track, at margin of highway; iron post stamped "283 B"	282.843
Traver, 3.5 miles south of, 9 feet south of milepost 236, west side of track, at margin of highway; iron post stamped "271 B"	271.422
Milepost 239, 10 feet south of, west side of track, at margin of highway; iron post stamped "280 B"	278.982
Goshen, in front of station; top of rail	283.5
Goshen, 1.4 miles south of, opposite milepost 242, east side of track, at margin of highway; iron post stamped "286 B"	286.338
Milepost 245, 10 feet south of, west side of track; iron post stamped "293 B"	292.787
Milepost 248, opposite, east side of track, at margin of fence line; iron post stamped "293 B"	293.350
Tulare, at crossing of Santa Fe Railway; top of rail	288.3
Tulare, 10 feet south of northeast corner of public library fence, 200 feet south of milepost 251, west side of track; iron post stamped "285 B"	284.721
Tulare, in front of station; top of rail	287.3
Tulare, 2.9 miles south of, 10 feet south of milepost 254, west side of track, at margin of highway; iron post stamped "269 B"	269.180
Milepost 257, 4 feet north of, west side of track, at margin of highway fence; iron post stamped "266 B"	266.208
Milepost 260, opposite, east side of track, at fence line for east margin of highway; iron post stamped "266 B"	266.463
Tipton, in front of station; top of rail	272.0

	Feet.
Tipton, 1.4 miles south of, east side of track, at fence line, opposite milepost 263; iron post stamped "277 B"	277.271
Tipton, 4.4 miles south of, west side of track, opposite milepost 266; iron post stamped "272 B"	272.616

FAMOSO QUADRANGLE.

Pixley, in front of station; top of rail	274.3
Milepost 269, 15 feet south of, west side of track, at fence line; iron post stamped "275 B"	275.217
Milepost 272, opposite, east side of track, at margin of fence; iron post stamped "276 B"	276.222
Milepost 275, opposite, west side of track, at margin of fence; iron post stamped "293 B"	293.023
Milepost 278, opposite, west side of track, at margin of fence; iron post stamped "303 B"	303.631
Delano, 0.8 mile north of, opposite milepost 281, west side of track at margin of fence; iron post stamped "316 B"	316.644
Delano, in front of station; top of rail	318.7
Delano, 2.1 miles south of, 12 feet south of milepost 284, west side of track; iron post stamped "307 B"	307.151
Milepost 287, 12 feet south of, west side of track, at margin of highway; iron post stamped "342 B"	341.928
Milepost 290, 12 feet south of, west side of track; iron post stamped "376 B"	376.643
Famoso, 0.7 mile north of, opposite milepost 293, east side of track, at margin of highway; iron post stamped "415 B"	415.479
Famoso, in front of station; top of rail	423.4
Milepost 296, opposite, east side of track, at margin of highway; iron post stamped "439 B"	439.004
Milepost 299, opposite, 45 feet east of track; iron post stamped "442 B"	442.320
Milepost 302, opposite, 40 feet east of track; iron post stamped "415 B"	415.086

BAKERSFIELD SPECIAL (BAKERSFIELD 30′) QUADRANGLE.

Milepost 305, opposite, 43 feet east of track; iron post stamped "427 B"	427.798
Jewetta, in front of station; top of rail	453.9
Jewetta, 1 mile southeast of, opposite milepost 308, 40 feet east of track; iron post stamped "448 B"	448.386
Milepost 312, opposite, on east side of track, at fence line; iron post stamped "409 B"	409.937

BAKERSFIELD, VIA SOUTHERN PACIFIC RAILROAD, TO TEHACHAPI.

BAKERSFIELD SPECIAL (CALIENTE 30′) QUADRANGLE.

Bakersfield (Kern station), 130 feet east of northeast corner of station, at south end of highway and corner of fence; iron post stamped "421 B"	421.877
Bakersfield (Kern station), in front of station; top of rail	420.7

CALIENTE 30′ QUADRANGLE.

	Feet.
Milepost 317, 12 feet south of, on west side of track, at margin of highway; iron post stamped "431 B"	431.898
Milepost 320, 12 feet south of, on west side of track, at margin of highway; iron post stamped "509 B"	510.070
Milepost 323, 12 feet south of, on west side of track; iron post stamped "660 B"	660.929
Milepost 326, opposite, east side of track, at fence line; iron post stamped "864 B"	864.992
Pampa, 30 feet west of station, on east side of track, at fence line; iron post stamped "874 B"	874.815
Pampa, in front of station; top of rail	875.9
Milepost 332, 370 feet south of, east side of track, at fence line; iron post stamped "1014 B"	1,015.446
Milepost 335, 65 feet south of, 10 feet east of track; iron post stamped "1201 B"	1,202.070
Caliente, 1.6 miles south of, 10 feet south of milepost 338, on west side of track; iron post stamped "1402 B"	1,403.527
Milepost 341, opposite, on east side of track, at margin of fence; iron post stamped "1732 B"	1,733.688
Bealville, crossing at station; top of rail	1,806.4
Milepost 344, 100 feet north of, 25 feet east of track; iron post stamped "2054 B"	2,055.255
Milepost 347, 150 feet south of, 60 feet west of track, 20 feet east of fence; iron post stamped "2395 B"	2,396.987
Keene, in front of station; top of rail	2,711.7
Keene, 360 feet south of station, 30 feet west of track, at milepost 350; iron post stamped "2719 B"	2,721.489
Milepost 353, 360 feet south of, on west side of track, 20 feet south of crossing; iron post stamped "3064 B"	3,066.522

MOHAVE QUADRANGLE.

Girard, in front of station; top of rail	3,295.6
Girard, 0.9 mile south of, on east side of track, opposite milepost 356, 12 feet from fence; iron post stamped "3396 B"	3,398.433

TEHACHAPI, VIA SOUTHERN PACIFIC RAILROAD, TO MOHAVE.

MOHAVE QUADRANGLE.

Milepost 359, 5 feet from, 20 feet west of track; iron post stamped "3732 B"	3,734.298
Tehachapi, in front of station; top of rail	3,969.4
Tehachapi, at station, 30 feet north of track, 15 feet east of highway; iron post stamped "3966 B"	3,969.255
Tehachapi, summit; top of rail	4,030.0
Milepost 365, 12 feet south of, on west side of track, at margin of highway; iron post stamped "3995 B"	3,997.981
Milepost 368, opposite, on east side of track, at margin of highway; iron post stamped "3920 B"	3,922.709
Cameron, in front of station; top of rail	3,792.0
Cameron, 150 feet south of station, on west side of track, at margin of fence; iron post stamped "3790 B"	3,792.997

	Feet.
Milepost 374, opposite. 80 feet east of track; iron post stamped "3586 B"	3,588.914
Mohave, 4.7 miles north of, west side of track, 40 feet from milepost 377; iron post stamped "3272 B 1902"	3,273.919
Mohave, 2.7 miles north of, 70 feet north of milepost 379, on west side of railroad; iron post stamped "3030 B 1902"	3,032.494

MOHAVE, ALONG SOUTHERN PACIFIC RAILWAY, TO PACOIMA.

MOHAVE QUADRANGLE.

Mohave, in front of station; top of rail	2,757.0
Mohave, 0.4 mile south of, 25 feet north of milepost 382, on west side of railroad; iron post stamped "2732 B 1902"	2,733.451

PALMDALE QUADRANGLE.

Rosamond, 10.4 miles north of, 12 feet south of milepost 385, on west side of railroad; iron post stamped "2639 B 1902"	2,641.311
Rosamond, 7.4 miles north of, 15 feet south of milepost 388, on east side of track; iron post stamped "2561 B 1902"	2,562.911
Rosamond, 4.4 miles north of, 10 feet south of milepost 391, on west side of track; iron post stamped "2543 B 1902"	2,544.409
Rosamond, 1.4 miles north of, 10 feet south of milepost 394, on west side of track; iron post stamped "2407 B 1902"	2,408.948
Rosamond, in front of station; top of rail	2,328.0
Lancaster, 9.6 miles north of, west of track, 12 feet south of milepost 397; iron post stamped "2311 B 1902"	2,312.885
Lancaster, 6.6 miles north of, 10 feet south of milepost 400, on west of track; iron post stamped "2302 B 1902"	2,304.022
Lancaster, 3.6 miles north of, at milepost 403, west side of track; iron post stamped "2302 B 1902"	2,303.913
Lancaster, 0.6 mile north of, 10 feet south of milepost 406, west of track; iron post stamped "2335 B 1902"	2,336.389
Lancaster, in front of station; top of rail	2,357.0
Palmdale, 5.9 miles north of, 50 feet from track, opposite milepost 409, on east side of track; iron post stamped "2462 B 1902"	2,463.882
Palmdale, 2.9 miles north of, 10 feet north of milepost 412, on west side of track; iron post stamped "2592 B 1902"	2,593.314
Palmdale, 150 feet north of station, on east side of track, telegraph pole; iron post stamped "2657 B 1902"	2,658.623
Harold, 165 feet north of water tank, at north end of section house fence, on east side of track; iron post stamped "2824"	2,826.028

TUJUNGA QUADRANGLE.

Vincent, 500 feet north of station, 500 feet west of center line of T. 5 N., R. 12 W., in corner of jog in fence; iron post stamped "3219"	3,219.258
Acton, southwest corner of hotel, in brick wall; bronze tablet stamped "2700"	2,700.771
Ravenna, 58 feet east of station office door, 35 feet from gum tree, on east side of track; iron post stamped "2468"	2,468.188

FERNANDO QUADRANGLE.

	Feet.
Lang, between hotel building and section house, 45 feet north of center of track; iron post stamped "1690"	1,689.544

SANTA SUSANA QUADRANGLE.

Saugus (Surrey post-office), 18 feet from north corner of pump house, 18 feet from center of track, 33 feet from south corner of station building; iron post stamped "1171"	1,170.641
Newhall, 27 feet south of station, 30 feet from center of track, between tree and telegraph pole; iron post stamped "1273"	1,272.195
Fernando tunnel, 0.25 mile south of south end of, at end of yard at section house; iron post stamped "1417"	1,416.373

FERNANDO QUADRANGLE.

Fernando, Maclay & Maclay Company's building on Johnson street, in southeast corner of brick wall; bronze tablet stamped "1066"	1,066.665
Pacoima, 165 feet northwest of northwest corner of brick station building, at corner of fence; iron post stamped "1013"	1,013.230

CHICO, DAVISVILLE, KNIGHTS LANDING, MARYSVILLE, RED BLUFF, REDDING, SHASTA, TEHAMA, VINA, AND WOODLAND QUADRANGLES.

BUTTE, PLACER, SHASTA, SISKIYOU, SUTTER, TEHAMA, YOLO, AND YUBA COUNTIES.

The elevations in the following list are a portion of the results of a double-simultaneous precise-level line run in 1902–3 by Mr. C. H. Semper, levelman, from Benicia, Cal., north along Southern Pacific Railroad to Portland, Oreg.

As originally computed and corrected for rod error, in accord with previous rating, it made a closure of 0.420 foot low on the elevation brought from Astoria to Portland by J. H. Carlock in 1898, but recent rerunning near Mohave over a precise line on which the same rods were used as on this line, on portion from Benicia to near Shasta Springs (where new rods were substituted at 2,650-foot elevation), showed an additional rod correction necessary to be applied of 0.0006 foot per vertical foot, increasing differences, and this would increase the elevation for Shasta Springs 1.59 feet, making a closure of 1.17 high at Portland. As a matter of adjustment the previous adjusted elevations by this line from Benicia to near Kennett were retained, the correction at Kennett being +0.13 at 680-foot elevation, and rod corrections applied thence to Shasta Springs make the correction to near Shasta Springs +1.3 feet, leaving 0.88 foot error, which has been adjusted between the latter place and Portland, a distance of 440 miles, at the rate of 0.002 foot per mile. A Buff & Berger precise level and two double-faced 10-foot nonextensible target rods were used.

Elevations in Oregon are not included, and elevations between Benica and Davisville, Cal., are given in other lists, pages 13–14.

DAVIS, NORTH TO WOODLAND.

DAVISVILLE QUADRANGLE.

	Feet.
Davis, 0.4 mile east of, on south side of railroad, 5 feet from milepost 77; iron post stamped "42 B 1902"	42.095

WOODLAND QUADRANGLE.

Davis, 3.2 miles north of, on east side of railroad, 30 feet north of milepost 80; iron post stamped "48 B 1902"	48.400
Davis, 6.1 miles north of, on east side of railroad, 300 feet north of milepost 83, at railroad crossing; iron post stamped "53 B 1902"	53.315
Woodland, at southeast corner of railroad park at station, 5 feet north of water tank; iron post stamped "60 B 1902"	60.260
Woodland, near station, at railroad crossing; top of rail	60.8

WOODLAND TO MARYSVILLE.

WOODLAND QUADRANGLE.

Woodland, 2.6 miles north of, on east side of railroad, at fence line, at milepost 89; iron post stamped "62 B 1902"	61.589

KNIGHTS LANDING QUADRANGLE.

Woodland, 5.6 miles north of, on east side of railroad, at milepost 92, at fence line; iron post stamped "30 B 1902"	30.201
Knights Landing, in front of station; top of rail	36.7
Knights Landing, at railroad station, 30 feet east of track, at corner of highway and on line of north side of station; iron post stamped "32 B 1902"	31.825
Knights Landing, 5 miles north of, on west side of railroad, 6 feet from rail, opposite milepost 100; iron post stamped "37 B 1902"	37.432
Knights Landing, 8.1 miles north of, on west side of railroad, 10 feet from tract, opposite milepost 103; iron post stamped "38 B 1902"	38.006
Chandler, in front of station; top of rail	36.4
Marcuse, 0.4 mile north of, on west side of railroad at fence line, 5 feet north of milepost 109; iron post stamped "33 B 1902"	32.878
Tudor, 0.2 mile south of, on west side of railroad, at fence line, 5 feet north of milepost 112; iron post stamped "40 B 1902"	39.844

MARYSVILLE QUADRANGLE.

Tudor, in front of station; top of rail	39.9
Tudor, 2.8 miles north of, on west side of railroad, at fence line, 5 feet north of milepost 115; iron post stamped "43 B 1902"	43.431
Tudor, 5.8 miles north of, on west side of railroad, at fence line, 5 feet north of milepost 118; iron post stamped "53 B 1902"	53.073
Tudor, 8.8 miles north of, on west side of railroad, at fence line, 5 feet norta of milepost 121; iron post stamped "58 B 1902"	57.712
Yuba City, in front of station; top of rail	57.5
Marysville, at railroad station, 225 feet west of track, at southeast corner of railroad park; iron post stamped "61 B 1902"	61.202

MARYSVILLE TO RED BLUFF.

MARYSVILLE QUADRANGLE.

	Feet.
Marysville, 2.8 miles north of, on east side of railroad, 300 feet north of long trestle, 10 feet east of track, opposite milepost 145; iron post stamped "72 B 1902"	71.774
Marysville, 5.7 miles north of, on east side of railroad, 4 feet north of milepost 148, at fence line; iron post stamped "66 B 1902"	66.420
Marysville, 8.7 miles north of, on east side of railroad, at fence line, 4 feet north of milepost 151; iron post stamped "73 B 1902"	73.520
Live Oak, in front of station; top of rail	75.8
Live Oak, 2 miles north of, on east side of railroad, 5 feet north of milepost 155; iron post stamped "82 B 1902"	81.873
Live Oak, 5 miles north of, on east side of railroad, at road crossing, 30 feet south of milepost 158; iron post stamped "92 B 1902"	92.520
Gridley, in front of station; top of rail	92.7
Gridley, 1.7 miles north of, on east side of railroad, 480 feet north of milepost 161, at fence line; iron post stamped "90 B 1902"	90.191
Biggs, in front of station; top of rail	93.7
Biggs, 1.3 miles north of, on west side of railroad, 900 feet north of milepost 164, 50 feet west of track, at telegraph pole; iron post stamped "91"	90.789
Biggs, 4.2 miles north of, on east side of railroad, 5 feet north of milepost 167; iron post stamped "99 B 1902"	98.900

CHICO QUADRANGLE.

Biggs, 7.1 miles north of, on east side of railroad, 5 feet north of milepost 170; iron post stamped "107 B 1902"	107.543
Nelson, in front of station; top of rail	121.0
Nelson, 700 feet north of station, on east side of railroad, 5 feet north of milepost 173; iron post stamped "120 B 1902"	119.767
Nelson, 3.1 miles north of, on east side of railroad, 4 feet north of milepost 176; iron post stamped "128 B 1902"	128.010
Durham, 0.4 mile south of, on east side of railroad, 270 feet north of milepost 179, 5 feet from telephone pole; iron post stamped "152 B 1902"	152.298
Durham, in front of station; top of rail	159.1
Durham, 2.5 miles north of, on east side of railroad, 5 feet north of milepost 182; iron post stamped "182 B 1902"	181.879
Chico, 0.5 mile south of, on east side of railroad, 5 feet north of milepost 185; iron post stamped "185 B 1902"	184.842
Chico, in front of station; top of rail	188.7
Chico, State Normal School, southwest corner of building, front face; aluminum tablet stamped "201 B 1902"	200.776
Chico, 3.4 miles north of, on east side of railroad, 5 feet north of milepost 189; iron post stamped "156 B 1902"	155.696
Chico, 6.4 miles north of, on east side of railroad, 5 feet north of milepost 192; iron post stamped "145 B 1902"	144.810
Nord, in front of station; top of rail	148.4
Nord, 2.3 miles north of, on east side of railroad, 5 feet north of milepost 195; iron post stamped "156 B 1902"	156.086

VINA QUADRANGLE.

	Feet.
Cana, in front of station; top of rail	168.1
Cana, 0.7 mile north of, on east side of railroad, 3 feet north of milepost 198; iron post stamped "169 B 1902"	169.142
Cana, 3.6 miles north of, east side of railroad, 3 feet north of milepost 201; iron post stamped "179 B 1902"	179.088
Vina, 0.4 mile south of, on east side of railroad, 3 feet north of milepost 204; iron post stamped "202 B 1902"	202.206
Vina, in front of station; top of rail	206.4
Vina, 2.6 miles north of, on east side of railroad, 225 feet north of milepost 207, 12 feet from fence; iron post stamped "201 B 1902"	201.514

TEHAMA QUADRANGLE (RED BLUFF 1° QUADRANGLE).

Vina, 5.5 miles north of, on east side of railroad, 4 feet north of milepost 210; iron post stamped "210 B 1902"	210.571
Tehama, 450 feet south of station, 4 feet north of milepost 213, on east side of railroad; iron post stamped "213 B 1902"	213.107
Tehama, in front of station; top of rail	217.5
Tehama, 3 miles north of, on east side of railroad, 3 feet north of milepost 216; iron post stamped "237 B 1902"	237.512
Proberta, in front of station; top of rail at crossing	252.5
Proberta, 1.7 miles north of, on east side of railroad, 3 feet north of milepost 219; iron post stamped "266 B 1902"	266.035
Proberta, 4.7 miles north of station, on east side of railroad, 3 feet north of milepost 222; iron post stamped "291 B 1902"	289.889

RED BLUFF TO DUNSMUIR.

TEHAMA QUADRANGLE (RED BLUFF 1° QUADRANGLE).

Red Bluff, in front of station; top of rail	303.6
Red Bluff, at Crittington-street crossing, on north margin of road, 50 feet east of track, at milepost 225; iron post stamped "309 B 1902"	308.797

RED BLUFF 1° QUADRANGLE.

Red Bluff, 3.1 miles north of, on east side of railroad, 300 feet north of milepost 228, 15 feet from fence; iron post stamped "370 B 1902"	369.720
Red Bluff, 6 miles north of, on east side of railroad, 100 feet south of milepost 231, at telegraph pole; iron post stamped "437 B 1902"	437.073
Red Bluff, 9 miles north of, on east side of railroad, 400 feet north of milepost 234, at fence line; iron post stamped "591 B 1902"	591.014
Hooker, in front of station; top of rail	538.9
Hooker, 1.8 miles north of, 110 feet north of milepost 237, 30 feet west of track, at telegraph pole; iron post stamped "491 B 1902"	491.195
Hooker, 4.7 miles north of, on east side of railroad, 3 feet north of milepost 240; iron post stamped "433 B 1902"	433.244
Cottonwood, in front of station; top of rail	417.5

	Feet.
Cottonwood, 1 mile north of, on east side of railroad, 150 feet north of milepost 243, at telegraph pole; iron post stamped "421 B 1902"	421.134
Cottonwood, 5 miles north of, on east side of railroad, 3 feet north of milepost 247; iron post stamped "464 B 1902"	464.464
Anderson, in front of station; top of rail	428.0
Anderson, 1.3 miles north of, on east side of railroad, 150 feet south of milepost 250, at telegraph pole; iron post stamped "434 B 1902"	434.277
Anderson, 4.3 miles north of, on east side of railroad, 300 feet north of milepost 253, at telegraph pole; iron post stamped "470 B 1902"	470.128

REDDING QUADRANGLE (RED BLUFF 1° QUADRANGLE).

Anderson, 7.2 miles north of, on east side of railroad, 3 feet north of milepost 256; iron post stamped "474 B 1902"	474.066
Redding, 0.7 mile south of, on east side of railroad, 4 feet south of milepost 259; iron post stamped "532 B 1902"	531.804
Redding court-house, first angle of wall on north side of east entrance; aluminum tablet stamped "590 B 1902"	589.658
Middle Creek, in front of station; top of rail	521.8
Middle Creek (Waugh post-office), 600 feet north of station, 15 feet west of track, at telegraph pole opposite hotel; iron post stamped "521 B 1902"	521.299
Keswick, in front of station; top of rail	562.9
Keswick, 0.6 mile north of, 100 feet north of milepost 266, 12 feet east of railroad telegraph pole; iron post stamped "569 B 1902"	569.310
Copley, 5 feet south of southwest corner of schoolhouse (Flat Creek district); iron post stamped "729 B 1902"	729.476
Copley, at freight house; top of upper rail	595.4
Copley, 3.4 miles north of, 15 feet south of railroad, 150 feet west of milepost 273; iron post stamped "628 B 1902"	627.714
Kennett, 1.3 miles west of, on east side of railroad, 100 feet south of milepost 276, at telegraph pole; iron post stamped "654 B 1902"	654.141
Kennett, in front of station; top of rail	665.3
Kennett, 1.8 miles north of, on east side of railroad, 300 feet north of milepost 279, at telegraph pole; iron post stamped "679 B 1902"	678.728
Kennett, 4.8 miles north of, on east side of railroad, 300 feet north of milepost 282, at telegraph pole; iron post stamped "722 B 1902"	722.492
Elmore, 3 feet west of fence west of Schoonover's house, 900 feet east of center of railroad trestle over Sacramento River, 58 feet south of tracks; iron post stamped "789 B 1902"	788.741
Elmore, in front of station sign; top of rail	795.8
Elmore, 3.7 miles north of, on east side of railroad, 5 feet from milepost 289; iron post stamped "901 B 1902"	901.600
Baird (Gregory post-office), railroad crossing at station; top of rail	962.3
Baird, 12 feet south of southeast corner of Smithson schoolhouse; iron post stamped "1022 B 1902"	1,022.643
Baird, 2.9 miles north of, on east side of railroad, 300 feet north of milepost 295, at telegraph pole; iron post stamped "1034 B 1902"	1,034.630
Delta, in front of station; top of rail	1,133.6

	Feet.
Delta, in front of schoolhouse, 3 feet north of center of porch, 100 feet south of Oregon road; iron post stamped "1319 B 1902"	1,319.608
Lamoine, 600 feet south of store, 20 feet south of bridge over stream, on east side of railroad, at telegraph pole; iron post stamped "1236 B 1902"	1,236.822
Lamoine, 2.1 miles north of, on east side of railroad, 8 feet north of milepost 304; iron post stamped "1320 B 1902"	1,320.737

SHASTA 1° QUADRANGLE.

Lamoine, 4.9 miles north of, on east side of railroad, 300 feet south of bridge No. 8 over Sacramento River, 10 feet north of telegraph pole; iron post stamped "1449 B 1902"	1,449.966
Sims, 1 mile south of, on east side of railroad, 300 feet south of milepost 310, at telegraph pole; iron post stamped "1607 B 1902"	1,608.010
Sims, in front of station; top of rail	1,669.9
Sims, 2 miles north of, on east side of railroad, 540 feet north of milepost 313, at telegraph pole; iron post stamped "1779 B 1902"	1,780.082
Sims, 5 miles north of, on east side of railroad, 300 feet north of milepost 316, at telegraph pole; iron post stamped "1900 B 1902"	1,900.900
Castella, in front of station; top of rail	1,943.6
Castella, 2.1 miles north of, on east side of railroad, 7 feet north of milepost 319; iron post stamped "2056 B 1902"	2,057.044
Castle Crag, in front of station; top of rail	2,091.8
Castle Crag, 2.1 miles north of, on east side of railroad, 150 feet north of milepost 322, 7 feet from telegraph pole; iron post stamped "2186 B 1902"	2,187.316
Dunsmuir, in front of station; top of rail	2,284.1

DUNSMUIR TO OREGON STATE LINE.

SHASTA 1° QUADRANGLE.

Dunsmuir, 1 mile north of, at upper Soda Springs flag station, 10 feet east of railroad, at corner of station; iron post stamped "2355 B 1902"	2,356.559
Shasta Springs, in front of station; top of rail	2,539.1
Shasta Springs, 1.1 miles north of, on east side of railroad, 5 feet from milepost 331; iron post stamped "2650 B 1902"	2,651.671
Shasta Springs, 4.1 miles north of, on east side of railroad, 5 feet from milepost 331; iron post stamped "2942 B 1902"	2,943.629
Mott, 35 feet south of station, on east side of railroad, 3 feet south of milepost 333; iron post stamped "3154 B 1902"	3,154.768
Mott, in front of station; top of rail	3,154.1
Mott, 2.8 miles north of, on east side of railroad, 4 feet north of fourth telegraph pole south of milepost 336; iron post stamped "3392 B 1902"	3,393.326
Sisson, in front of station; top of rail	3,553.0
Sisson, 0.6 mile north of, on east side of railroad, 150 feet north of milepost 339, 4 feet from telegraph pole; iron post stamped "3596 B 1902"	3,597.008
Upton, in front of station; top of rail	3,703.9

	Feet.
Upton, 2.3 miles north of, on east side of railroad, 8 feet from milepost 343; iron post stamped "3791 B 1902"	3,792.039
Upton, 5.4 miles north of, on east side of railroad, 10 feet from milepost 346; iron post stamped "3879 B 1902"	3,879.906
Igerna, in front of station; top of rail	3,732.7
Igerna, 1.6 miles north of, on west side of railroad, opposite milepost 349, 5 feet from telegraph pole; iron post stamped "3568 B 1902"	3,568.712
Weed, 1.9 miles north of, on east side of railroad, 2 feet from milepost 352; iron post stamped "3255 B 1902"	3,256.716
Edgewood, 600 feet south of station, on east side of railroad, at milepost 355; iron post stamped "2957 B 1902"	2,958.389
Edgewood, in front of station; top of rail	2,950.0
Edgewood, 2.8 miles north of, on east side of railroad, 5 feet north of milepost 358; iron post stamped "2909 B 1902"	2,910.178
Edgewood, 5.8 miles north of, on east side of railroad, 2 feet from milepost 361; iron post stamped "2824 B 1902"	2,825.403
Gazelle, in front of station; top of rail	2,756.8
Gazelle, 1.3 miles north of, on east side of railroad, 3 feet from milepost 364; iron post stamped "2717 B 1902"	2,718.258
Gazelle, 4.3 miles north of, on east side of railroad, at milepost 367; iron post stamped "2625 B 1902"	2,626.212
Gazelle, 7.2 miles north of, on east side of railroad, at milepost 370; iron post stamped "2554 B 1902"	2,555.433
Gazelle, 10.3 miles north of, on east side of railroad, at milepost 373; iron post stamped "2524 B 1902"	2,525.110
Montague, 1 mile south of, on east side of railroad, second telegraph pole north of milepost 376; iron post stamped "2518 B 1902"	2,518.845
Montague, in front of station; top of rail	2,538.4
Montague, 1.8 miles north of, on east side of railroad, at milepost 379; iron post stamped "2563 B 1902"	2,563.776
Montague, 4.8 miles north of, on east side of railroad, at first telegraph pole north of milepost 382; iron post stamped "2658 B 1902"	2,658.892
Montague, 7.7 miles north of, on east side of railroad, at first telegraph pole south of milepost 385; iron post stamped "2544 B 1903"	2,544.622
Ager, in front of station; top of rail	2,330.9
Ager, 800 feet north of station, on east side of railroad, at milepost 388; iron post stamped "2322 B 1903"	2,323.609
Ager, 3 miles north of, on west side of railroad, at milepost 391; iron post stamped "2115 B 1903"	2,115.804
Hornbrook, 0.8 mile south of, on west side of railroad, 200 feet south of milepost 394, at fence line; iron post stamped "2114 B 1903"	2,115.298
Hornbrook, in front of station; top of rail	2,151.7
Hornbrook, 2.2 miles north of, on east side of railroad, 30 feet north of milepost 397, at fence line; iron post stamped "2306 B 1903"	2,306.975
Hornbrook, 5.1 miles north of, on west side of railroad, 240 feet south of milepost 400, at telegraph pole; iron post stamped "2786 B 1903"	2,786.767
Hornbrook, 8.2 miles north of, on west side of railroad, at telegraph pole, opposite milepost 403; iron post stamped "2897 B 1903"	2,898.176
Cole, in front of station; top of rail	2,862.8

PRIMARY LEVELING.

ELSINORE, FLOWING WELL, INDIO SPECIAL, REDLANDS, SALTON, SAN BERNARDINO, SAN JACINTO, AND YUMA QUADRANGLES.

RIVERSIDE, SAN BERNARDINO, AND SAN DIEGO COUNTIES.

The purpose of this double primary line was to establish bench marks at Yuma and to determine their elevations above mean sea level by direct connection with tidal gage.

The following elevations are the result of primary leveling by Mr. R. A. Farmer, October, 1902, to January, 1903, beginning at Colton at a bronze tablet stamped "978," set horizontally in brick wall over corner pier of the Transcontinental Hotel. The elevation originally accepted for this bench mark was determined by a double-rodded primary line run from San Pedro to San Bernardino, published in the Appendix to the Nineteenth Annual Report, but the value then given is now considered to be 0.7 foot too small. The elevation of this bench mark is now accepted as 979.073 feet above mean sea level as derived by connection at San Bernardino with the above line by precise leveling of 1906 of the United States Coast and Geodetic Survey from a more reliable tidal record at Point Loma near San Diego.

The portion of this line from Colton to Montmere is a single rerunning of a line previously run, as published in Appendix to the Nineteenth Annual Report, a second rerunning being made when local divergences were excessive.

From Montmere to Yuma the line, as it progressed, was checked by running forward a certain distance and then back over the same section. If there was a discrepancy in feet of more than $0.05\sqrt{\text{circuit mileage}}$ between the two determinations the section was rerun a third time or more, until satisfactory results were obtained. At Yuma checks were obtained with the levels of the International boundary, as well as those of the Southern Pacific Company, the United States Geological Survey elevation being 0.2 foot lower than that obtained from the Southern Pacific Company, corrected to mean sea level for the bridge seat of the bridge across the Colorado River, and 0.18 foot lower than that obtained from the International Boundary Report by connection with monument No. 207 of the International boundary line.

COLTON, ALONG SOUTHERN PACIFIC RAILROAD, TO YUMA, ARIZ.

SAN BERNARDINO QUADRANGLE.

	Feet.
Colton, in front wall of Transcontinental Hotel; bronze tablet stamped "978 S B"	979.073
Mound City, reservoir east of depot, northeast corner of wall; copper bolt stamped "1079 S B"	1,079.762

REDLANDS QUADRANGLE.

	Feet.
Redlands Junction, east of station, west side of county road, and south line of Southern Pacific Company's right of way; iron post stamped "1201 S B"	1,201.693
Brookside, west of siding, west side of county road, at southeast corner of Brookside vineyard; iron post stamped "1301 S B"	1,301.906

ELSINORE QUADRANGLE.

San Timoteo district school; northwest corner of grounds; iron post stamped "1910 S B"	1,911.237
T. 3 S., between Rs. 2 and 1 W., north side of county road; iron post stamped "2297 S B"	2,297.835

SAN JACINTO QUADRANGLE.

Beaumont, Gray's brick store and warehouse, in the front wall at northwest corner: bronze tablet stamped "2575 S B"	2,575.909
Banning, opposite Hotel Banning, in east wall of Frayer brick block; bronze tablet stamped "2330 S B"	2,330.516
Cabezon, 7 feet east of southeast corner of section house, grounds north of track, in corner of stone-bordered walk; iron post stamped "1791 S B"	1,791.579
T. 3 S., between Rs. 2 and 3 E., east of road crossing on north side of Southern Pacific Company's right of way; iron post stamped "1442 S B"	1,442.584
Whitewater Siding, south of track, at northeast corner of section house grounds; iron post stamped "1130 S B"	1,130.633
Palm Springs, 170 feet east of station, at east end of row of palm trees, 13 feet south of track; iron post stamped "685 T"	686.055
Palm Springs, 3.5 miles southeast of, 45 feet west of track, 4 feet northwest of milepost 592; iron post stamped "539 T"	540.053

INDIO SPECIAL QUADRANGLE.

Rimlon, 0.16 mile southeast of signboard at section house, 45 feet southwest of track, near milepost 596; iron post stamped "342 T"	342.910
Dry Camp, 45 feet southwest of track, 90 feet west of switch at northwest end of siding; iron post stamped "164 T"	164.730
Myoma Siding, 100 feet west of, at west end of switch, 45 feet southwest of track; iron post stamped "70 T"	70.761
Indio, in southeast corner of schoolhouse yard; iron post stamped "15 T" (below mean sea level)	— 14.145
Woodspur, 50 feet southwest of track, at road crossing; iron post stamped "—66 T"	— 65.344
Thermal, 300 feet northwest of signboard, 45 feet southwest of track, 5 feet northwest of telegraph pole; iron post stamped "—121 T"	—120.087
Walters, 27 feet northwest of station, in corner of yard; iron post stamped "—189 T"	—188.341
Montmere, 100 feet southeast of, switch stand at west end of siding, 45 feet south of track, 4 feet south of wagon road, 4 feet west of telegraph pole; iron post stamped "—248 T"	—247.280

SALTON QUADRANGLE.

	Feet.
Salton, 50 feet north of post-office, 150 feet south of station, on railroad right of way line; iron post stamped "—257 SB"	—256.537
Durmid, in northeast corner of section-house ground: iron post stamped "—248 S B"	—247.060
Bertram, 50 feet south of railroad, 10 feet east of northeast corner of station; iron post stamped "—249 SB"	—247.796
Frink, 50 feet south of station, 6 feet east of milepost; iron post stamped "—258 SB"	—257.703
Volcano, in northeast corner of section-house grounds; iron post stamped "—221 S B"	—220.039
Old Beach, at west end of switch, 8 feet east of milepost 666: iron post stamped "—124 SB"	—122.899

FLOWING WELL QUADRANGLE.

Iris, 5 telegraph poles east of, 4 feet west of milepost 673; iron post stamped "77 SB" (above mean sea level)	77.257
Tortuga, 100 feet west of signboard, 4 feet east of milepost 677; iron post stamped "186 S B"	186.930
Milepost 680, 1,100 feet east of, 20 feet north of warning board at crossing; iron post stamped "220 SB"	220.800
Mammoth, 400 feet west of station, 50 feet south of railroad track; iron post stamped "259 S B"	259.610
Acolita, 50 feet south of track, 10 feet east of milepost 689; iron post stamped "271 S B"	271.376
Mesquite, 400 feet east of signboard at milepost 694; iron post stamped "295 S B"	295.249
Glamis, 1,800 feet east of station, 8 feet east of milepost 697; iron post stamped "338 S B"	338.690
Ruthven, 3 miles east of, east end of switch, 9 feet east of milepost 702; iron post stamped "379 S B"	379.380

YUMA QUADRANGLE.

Drylyn, 200 feet east of signboard, 8 feet east of milepost 708; iron post stamped "397 S B"	397.998
Cactus, 1,200 feet east of milepost 713, 4 feet west of signboard; iron post stamped "367 S B"	368.107
Ogilby, 300 feet west of section house, 6 feet east of milepost 715; iron post stamped "356 S B"	356.388
Knob, 200 feet west of station house; iron post stamped "294 SB"	294.741
Araz, 4 feet west of signboard; iron post stamped "156 S B"	157.126
Yuma, top of pier, north side of bridge over Colorado River; aluminum tablet stamped "137 S B"	138.100
Yuma, in front of passenger station; top of north rail	142.78

BLAISDELL, CAMP MOHAVE, EHRENBERG SPECIAL, NEEDLES SPECIAL, PARKER, PICACHO, AND YUMA QUADRANGLES.

RIVERSIDE, SAN BERNARDINO, AND SAN DIEGO COUNTIES.

The elevations in the following list are based upon a double primary-level line from San Bernardino to Yuma, based upon the United States Coast and Geodetic Survey precise-level line of 1906 from mean sea level at San Diego.

The leveling on Yuma quadrangle was done in 1902–3 under the direction of Mr. R. B. Marshall, topographer, by Messrs. C. J. Hoover, G. L. Gordon, and L. D. Ryus, levelmen; that on Picacho and Ehrenberg quadrangles was done in 1903 partly under Mr. Hersey Munroe, topographer, by E. W. Glafcke, levelman, and partly under Mr. Marshall by G. L. Gordon and L. D. Ryus; that on Parker quadrangle was done under Mr. Munroe partly in 1902–3 by Mr. Glafcke and partly in 1903 by Mr. S. E. Blout. That on Needles quadrangle was done partly in 1902 under Mr. E. C. Barnard, topographer, by Mr. H. Morrison, and partly in 1902–3 under Mr. Munroe by Messrs. Glafcke and Blout.

The leveling on Camp Mohave quadrangle was done in 1902 under Mr. Barnard by Mr. Morrison and that on quadrangle next to Parker in 1903 under Mr. Munroe by Mr. Blout.

YUMA QUADRANGLE.

YUMA, NORTHEAST ALONG WAGON ROAD, TO POTHOLES.

	Feet.
Yuma, 12.72 miles northeast of, 10 feet west of Yuma and Potholes road, north side of point of hill, south side of Pothole Canyon; iron post stamped "148 Y"	149.051

YUMA, NORTH ALONG ROAD, VIA MAGGIES WELL, TO PICACHO.

Maggies Well, T. 16 S., R. 22 E., southwest corner of section 1; iron post stamped "139 Y"	139.669
T. 15 S., R. 22 E., section 15, west side of road; iron post stamped "445 Y"	445.267
T. 14 S., R. 22 E., section 27, at intersection of stage road and small loop of road; iron post stamped "767 Y"	767.824
Picacho mine, 1.2 miles north of, on west side of road; iron post stamped "574 Y"	574.185

PICACHO, WEST ALONG PICACHO-YUMA ROAD, VIA AMERICAN MINE, TO OGILBY.

T. 15 S., R. 21 E., near southeast corner section 1, on north side of road; iron post stamped "635 Y"	636.051
American mine, 0.6 mile east of, on north side of road; iron post stamped "699 Y"	700.313

OGILBY, SOUTHWEST TO SAND HILLS (SINGLE SPUR LINE).

	Feet.
T. 16 S., R. 20 E., north side section 29, 5 miles southwest of Ogilby; iron post stamped "174 Y"	174.682

POINT 2 MILES NORTHEAST OF OGILBY, NORTH VIA HEDGE'S MINE 10 MILES (SINGLE SPUR LINE).

T. 14 S., R. 20 E., section 23, 4.3 miles north of Hedge's mine, 9.9 miles north of Ogilby; iron post stamped "697 Y"	698.233

ARAZ, SOUTHWEST TO MEXICAN BOUNDARY.

Monument No. 207; base of masonry[a]	155.96
Monument No. 207, on United States side; iron post stamped "155 Y"	156.024
Monument No. 206; base of masonry	119.37
Monument No. 206, in foundation, United States side; top of bolt	119.676

BLAISDELL QUADRANGLE.

POTHOLE, NORTH TO CASTLE DOME LANDING.

Castle Dome landing, 0.25 mile west of river, east side of road, at foot of hill; iron post stamped "165 Y"	165.943

PICACHO QUADRANGLE.

CASTLE DOME LANDING, NORTHWEST TO PICACHO.

Ferguson's old pumping plant, south side of hill at foot of bluff, 100 feet west of river bank; iron post stamped "177 Y"	177.239
Picacho cyanide plant, 1 mile northwest of, 0.5 mile north of schoolhouse, at point of hill west of road; iron post stamped "187 Y"	187.321

PICACHO, NORTHWARD ALONG WEST SIDE OF COLORADO RIVER, TO COMER'S RANCH.

Picacho, 8 miles north of, 33.90 miles south of Hodge's ranch, 20 feet east from road, in small saddle, 650 feet west of river, at upper end of large flat; iron post stamped "213 Y"	213.253
Hodge's ranch, 23.7 miles south of, 600 feet west of river, 150 feet east of cliffs, 50 feet west of road, north end of clearing in open flat; iron post stamped "208 Y"	208.919
Hodge's ranch, 18.5 miles south of, 30 feet west of road, on point of mesa 250 feet west of river; iron post stamped "224 Y"	224.388
Hodge's ranch, 14.68 miles south of, 10 feet west of forks of road, 500 feet southwest of old pumping station, at 4 tanks formerly used by Praymaster mine; iron post stamped "229 Y"	229.761
Hodge's ranch, 11.2 miles south of, 10 feet west of road, 750 feet north of Sobrino ranch, 200 feet due west of brush hut and corral; iron post stamped "232 Y"	232.536
Hodge's ranch, 3.5 miles southeast of, 25 feet east of road to Picacho, in small clearing in flat, 0.5 mile west of lagoon, 1 mile west of river; iron post stamped "227 Y"	227.374

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[a] Elevation by United States and Mexican Boundary Commission, 156.14 feet.

	Feet.
Hodge's ranch, 100 feet west of house, 200 feet west of lagoon, 300 feet south of county line between Santiago and Riverside counties, 15 feet west of road, in flat 19.7 miles southwest of Ehrensberg, Ariz.; iron post stamped "232 Y"	232.196
Ehrenberg, 13.8 miles southwest of, 1.54 miles south of Comer's ranch, at forks of road in open flat; iron post stamped "241 Y"	241.633

POINT 10 MILES NORTH OF PICACHO, ALONG ROAD MAKING CIRCUIT WEST, NORTH, AND EAST, TO POINT 12 MILES SOUTH OF HODGE'S RANCH.

Colorado River, 5.42 miles west of, half way between two triangulation signals on points in range of hills, on summit of divide at head of canyon; iron post stamped "1045 Y"	1045.954
Summit of divide, 5 miles north of, 6 miles west of river at forks of two large washes, in view of three triangulation signal points on west side of river and of one on east side of river; iron post stamped "713 Y"	713.650
Eagle oil well, 0.75 mile west of, 20 feet south of Ogilby and Palo Verde stage road; iron post stamped "561 Y"	561.750

POINT 2.5 MILES SOUTH OF HODGE'S RANCH, ALONG ROAD WEST AND NORTH, TO SALTON-EHRENBERG ROAD.

Palo Verde post-office, 6.24 miles west of, on black rock mesa, 2 miles east of Spring Peak; iron post stamped "583 Y"	583.887
Hodge's mine, 0.5 mile south of, 80 feet north of Salton-Ehrenberg road, 1 mile east of triangulation signal on point of mesa; iron post stamped "444 Y"	444.985

EHRENBERG SPECIAL QUADRANGLE.

COMER'S RANCH, NORTH ALONG ROAD ON WEST SIDE OF RIVER, TO EHRENBERG, ARIZ.

Ehrenberg, 8.5 miles southwest of, 1 miles west of river, 30 feet west of road, at site of old abandoned ranch; iron post stamped "253 Y"	252.733
Ehrenberg, 4.5 miles southwest of, 1.5 miles west of river, 15 feet west of road, in valley of Blythe estate, 600 feet north of wash; iron post stamped "258 Y"	258.395
Parker, 48 miles southwest of, 0.5 mile north of ranch house at forks of road, opposite and west of landing at Ehrenberg, 0.75 mile in open flat, 30 feet west of road; iron post stamped "269 Y"	270.338

OPPOSITE EHRENBERG, ARIZ., NORTH ALONG WEST SIDE OF RIVER, TO LA CRESENTA MINING COMPANY'S HOUSE.

Parker, 41 miles southwest of, 0.35 mile west of river, between forks of road to Blythe ranch and Ehrenberg, in open flat; iron post stamped "285 Y"	286.283
Parker, 36 miles southwest of, at east end of Santa Maria Mountains, 300 feet west of river, north end of Blythe estate, in limestone; bronze tablet stamped "299 Y"	299.933
Parker, 32.1 miles southwest of, 0.25 mile west of river, south side of road wash, on east edge of bare mesa, in large bowlder; bronze tablet stamped "334 Y"	334.817

	Feet.
Parker, 28 miles southwest of, 1.25 miles west of river, 1 mile northwest of cabin foot of mesa, edge of flat, in large bowlder; bronze tablet stamped "393 Y"	393.852
Parker, 23.2 miles southwest of, 500 feet west of river, at southeast end of Riverside range of mountains, in ledge of limestone, point of rocks; bronze tablet stamped "360 Y"	361.093
Parker, 18.2 miles southwest of, 40 feet east of northwest corner of adobe house of the La Cresenta Mining Company; bronze tablet stamped "364 Y"	364.320

NORTH ALONG SALTON-EHRENBERG ROAD, VIA BLYTHE TRIANGULATION STATION, TO POINT 8 MILES NORTH OF EHRENBERG.

	Feet.
Salton road, 5.98 miles north of, 3 miles west of Willow Springs, on edge of second bench of mesa; iron post stamped "384 Y"	384.547
Blythe triangulation station, 1 mile west of Mesquite Flat, at point of mesa; iron post stamped "390 Y"	391.035
Blythe ranch, 1 mile west of, 600 feet east of mesa, 20 feet east of Palo Verde, 10 feet south of road; iron post stamped "297 Y"	297.776

PARKER QUADRANGLE.

NORTHEAST ALONG ROAD TO OPPOSITE BILL WILLIAMS FORK, THENCE NORTHWEST ALONG ROAD TO LIVERPOOL LANDING.

	Feet.
Parker, 13.5 miles southwest of, top of mesa 0.5 mile west of river landing of Right & Lawrence Mining Company, 1.5 miles east of Riverside Mountain, in large bowlder set in ground; bronze tablet stamped "405 Y"	405.380
Parker, 8 miles southwest of, 0.25 mile west of river, opposite center of large island at head of big draw, on mesa; iron post stamped "415 Y"	415.918
Parker, 3.5 miles west of, 600 feet west of river, top of mesa, 400 feet due west of triangulation point, on edge of same; iron post stamped "410 Y"	410.731
Bill Williams Fork, 15.1 miles south of, 200 feet west of river, on east slope of mesa, 100 feet west of trail; iron post stamped "372 Y"	372.863
Bill Williams Fork, 10 miles south of, lower end of Empire Flats (California side of river), 700 feet west of river, 600 feet east of mesa in open flat; iron post stamped "370 Y"	370.865
Bill Williams Fork, 4.6 miles south of, 800 feet west of big bend in river at point in cliffs, lower end of Empire Flats (California side), in saddle; iron post stamped "412 Y"	412.458
Bill Williams Fork of the Colorado River, 1,200 feet due west of mouth of, 60 feet west of river, on west bank, on large mound of rock in ledge at foot of cliffs; bronze tablet stamped "400 Y"	401.010
Pete McGuire, 300 feet north of (California side of river); iron post stamped "401 Y"	402.308
Mellen, Ariz., 35 miles southeast of, 2.45 miles south of Tom Drennis stamp mill, 300 feet west of river, on east slope of mesa, in bowlder; bronze tablet stamped "414 Y"	415.330
Mellen, 30 miles southeast of, on west bank (California side) of river; bronze tablet stamped "417 Y"	417.619
Chemehuevis Valley, lower end of, west bank of river, on point of mesa; iron post stamped "437 Y"	438.036

LIVERPOOL LANDING, SOUTHWEST TO WEST WELL.

	Feet.
West Well, in Chemehuevis Valley, on east side of road to Parker, 50 feet north of pump; iron post stamped "762 Y"	762.309

POINT 11 MILES SOUTH OF WEST WELL, SOUTHEAST TO PARKER, ARIZ.

West Well, 11 miles south of, on west side of road, on summit of mountain; iron post stamped "1888 Y"	1,888.439
West Well, 15 miles south of, on west side of road; iron post stamped "1402 Y"	1,402.097
West Well, 21 miles south of, 5 miles west of Colorado River at point opposite Parker, on east side of road; iron post stamped "849 Y"	848.520

QUADRANGLE WEST OF PARKER.

NEEDLES TO WEST WELL, THENCE 11 MILES SOUTH.

West Well, 3 miles northwest of, on west side of road; iron post stamped "1048 Y"	1,048.925
West Well, 5 miles southwest of, on east side of road; iron post stamped "1232 Y"	1,233.121

NEEDLES SPECIAL QUADRANGLE.

LIVERPOOL LANDING, NORTH ALONG CALIFORNIA SIDE OF RIVER TO MELLEN, ARIZ.

Mellen, 15 miles southeast of, 0.45 mile west of river, 10 feet east of foot of mesa, in open flat; iron post stamped "431 Y"	431.547
Chemehuevis Valley, 2.5 miles northeast of triangulation signal at the northern end (California side) of, 600 feet west of Colorado River, near Mohave Rock; iron post stamped "437 Y"	438.060

MELLEN, NORTHWEST ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO NEEDLES.

Needles, 4.25 miles south of, on west side of railroad, 6 feet east of milepost 373; iron post stamped "473 Y 1903"	474.030

BENCH MARKS IN THE VICINITY OF NEEDLES.

Needles, Santa Fe station, at road crossing opposite dining room, west front; top of rail	481.646
Needles, U. S. Coast and Geodetic Survey, East Base, in stone monument; bronze tablet stamped "467 Y 1903"	467.292
Needles, U. S. Coast and Geodetic Survey, West Base, in stone monument; copper bolt (in top) stamped "U. S. G. S. B. M. 490"	491.082
Needles, U. S. Coast and Geodetic Survey, stone monument on Knoll triangulation station; point on southeast corner stamped "U. S. G. S. B. M. 680"	680.257
Needles, west corner of schoolhouse grounds, iron pipe in top of; concrete monument stamped "552 Y 1903"	552.487
Needles, U. S. Coast and Geodetic Survey monument in Catholic churchyard; bronze tablet stamped "503 Y 1903"	503.608

NEEDLES, NORTH 9 MILES (PART OF CIRCUIT TO FORT MOHAVE).

Needles, 3 miles northwest of, in sec. 13, T. 9 N., R. 22 E., on west side of road, west of river; iron post stamped "482 Y"	482.459
Needles, 8 miles northwest of, in sec. 22, T. 9 N., R. 22 E., on east side of road west of river; iron post stamped "488 Y"	488.276

NEEDLES, SOUTH ALONG ROAD, TO WEST WELL.

	Feet.
Needles, 5 miles south of, in sec. 20, T. 8 N., R. 23 E., on east side of road leading to Parker; iron post stamped "737 Y"	737.991
Needles, 10 miles south of, in sec. 7, T. 7 N., R. 23 E., on east side of road leading to Parker; iron post stamped "1215 Y"	1,215.367
Needles, 15 miles south of, on west side of road leading to Parker; iron post stamped "1933 Y"	1,934.152
Needles, 20 miles south of, on west side of road leading to Parker; iron post stamped "1906 Y"	1,906.584
Needles, 25 miles south of, 8 miles northwest of West Well, on west side of road; iron post stamped "1613 Y"	1,613.262

NEEDLES, NORTHWEST ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO KLINEFELT.

Needles, 7 miles northwest of, 80 feet east of section house at Java station; iron post stamped "968 Y"	969.168

QUADRANGLE WEST OF NEEDLES SPECIAL QUADRANGLE.

AT KLINEFELT STATION.

Klinefelt station, west side of track, opposite station signboard; iron post stamped "1213 Y"	1,213.414

CAMP MOHAVE QUADRANGLE.

FORT MOHAVE, SOUTH TO POINT 9 MILES NORTHWEST OF NEEDLES.

Fort Mohave, 4 miles southwest of, on road leading to Needles, on west side of river, at foot of knoll on west side of road; iron post stamped "479 Y"	479.544

HOLTVILLE, IMPERIAL, AND SALTON QUADRANGLES.

SAN DIEGO COUNTY.

The elevations in the following list are based on a secondary bench mark on the double primary-level line from San Bernardino to Yuma, a railroad spike in the base of milepost 667, 1 mile east of Old Beach station, Southern Pacific Railroad, 45 feet south of track, the accepted elevation being 104.360 feet below sea level.

The leveling was begun by Mr. W. V. Hardy, levelman, in 1904, and completed by Mr. S. N. Stoner, topographic aid, in 1905.

SALTON QUADRANGLE.

OLD BEACH, SOUTH ALONG SOUTHERN PACIFIC RAILROAD (IMPERIAL AND GULF BRANCH), TO ROCKWOOD SIDING.

	Feet.
Old Beach, 1 mile east of, milepost 667, 45 feet south of track; spike in base (below sea level)	—104.360
Alamo River, 200 feet north of railroad bridge, 45 feet east of track; iron post stamped "—162 Y"	—161.263
Rockwood siding, 2 feet east of signboard; iron post stamped "—157 Y"	—156.583

IMPERIAL QUADRANGLE.

BRAWLEY, SOUTH TO IMPERIAL.

	Feet.
Brawley, 0.5 mile north of, 3 feet east of milepost 684; iron post stamped "—117 Y"	—117.186
Brawley station, 60 feet north of, at street crossing; top of rail	—112.102
Brawley triangulation station; iron post stamped "—93 Y"	—92.374
Brawley, 3.5 miles south of, 5 feet south of milepost 688, west of track; iron post stamped "—119 Y"	—118.248
Imperial, 5 miles north of, at southwest corner of fence; iron post stamped "—91 Y"	—90.175
Imperial, 3 miles north of, 30 feet north of wagon-road bridge over arroyo, west of road under second bank; iron post stamped "—88 Y"	—87.138
Imperial, south wall of Imperial Hotel; bronze tablet stamped "—61 Y"	—59.853
Imperial triangulation, station, 2,000 feet north of railroad station, 40 feet south of spur, east of main track; iron post stamped "—66 Y"	—65.437

IMPERIAL, 1.8 MILES EAST TO CROSSROADS; THENCE SOUTH TO CALEXICO.

Imperial, 1.8 miles east of, in southeast angle of crossroads, 3 feet west of fence corner; iron post stamped "—67 Y"	—67.110
Holtville, 60 feet south of, at Interurban Railroad crossing, west of road, 10 feet north of fence corner; iron post stamped "—50 Y"	—49.121
Holtville, 2.9 miles south of, 100 feet south of Southern Pacific Railroad crossing, east of road; iron post stamped "—22 Y"	—21.186
Heber siding, 2 feet east of crossing signboard; iron post stamped "—14 Y"	—13.049

CALEXICO, WEST TO VICINITY OF INTERNATIONAL BOUNDARY MONUMENT NO. 221.

International boundary monument No. 221, northeast corner iron base	4.252
International boundary monument No. 221, 0.6 mile west of; on north bank of Wisteria canal; iron post stamped "4 Y"	4.859

BRAWLEY, WEST TO NEW RIVER.

Brawley, 1.5 miles west of, 80 feet east of New River Bridge, 30 feet south of road, 10 feet east of mesquite tree; iron post stamped "—133 Y"	—132.206

HOLTVILLE QUADRANGLE.

CALEXICO, NORTH 2 MILES.

Calexico, north wall of bank building; bronze tablet stamped "+5 Y"	5.644
Calexico, 2 miles north of, southwest corner of bridge over main canal; iron post stamped "+2 Y"	2.569

INTERNATIONAL BOUNDARY MONUMENT NO. 219, EAST TO HOLT CANAL.

Calexico, 10 miles east of, 100 feet north of Holt canal, 70 feet south of Hemlock canal, 45 feet north of telephone line; iron post stamped "35 Y"[a]	35.887

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[a] Bench mark determined by a single unchecked line.

CALEXICO, ACROSS COUNTRY TO INTERNATIONAL BOUNDARY MONUMENT NO. 215.

	Feet.
Calexico, 1.5 miles east of, International boundary monument No. 220, 2 feet east of; iron post stamped "6 Y" (from report, 1.804)	6.998
Calexico, 3.6 miles east of, north of road, west end of bridge over main canal; iron post stamped "17 Y"	18.134
Calexico, 4.6 miles east of, International boundary monument No. 219; top of bolt in base of shaft, north side (from report, 19.652)	25.046
Calexico, 4.6 miles east of, 6 feet north of Boundary monument No. 219; iron post stamped "26 Y"	26.942
Sharp triangulation station; iron post	60.693
Boundary monument No. 217; northeast corner of cement base (from report, 51.739)	55.782
Boundary monument No. 217, 9 feet north of; iron post stamped "56 Y"	56.878
Boundary monument No. 216, 1 mile west of; nail in top of 4 by 4 inch boundary stake	71.815
Boundary monument No. 215; northeast corner of cement base (from report, 93.144)	96.114
Boundary monument No. 215, 6 feet north of; iron post stamped "96 Y"	97.113

CABAKER JUNCTION, ALONG HOLTVILLE INTERURBAN RAILROAD TO HOLTVILLE; THENCE ALONG ROAD 2.8 MILES EAST; THENCE SOUTHEAST TO BOUNDARY MONUMENT NO. 215.

Brice siding, 75 feet east of east end of switch, 35 feet south of track; iron post stamped "—48 Y"	—47.419
Gleason siding, 45 feet south of track, midway between switch targets; iron post stamped "—58 Y"	—57.115
Holtville, at northeast corner of Alamo Hotel; bronze tablet stamped "—12 Y"	—9.114
Holtville, 2.8 miles east of, at corner of fence, 60 feet west of No. 5 canal; 1,000 feet north of drop in canal near township corner; iron post stamped "—7 Y"	—6.022
T. 16 S., R. 16 E., 400 feet west of quarter corner sec. 10, south side; iron post stamped "19 Y"	19.534

INTERNATIONAL BOUNDARY MONUMENT NO. 219, OVER MESA TO WAGON BRIDGE OVER ALIMITOS CANAL; THENCE ALONG COUNTY ROAD TO HOLTVILLE.

Boundary monument No. 219, 6 feet north of; iron post stamped "26 Y"	26.942
Alamitos canal, bridge near quarter corner between sections 28 and 33, 10 feet east of northeast corner; iron post stamped "12 Y"	12.648
Holtville, 1 mile south of, at triangulation station; top of iron post stamped "6 Y"	6.581

SUNSET SPRINGS, ACROSS COUNTRY AND ALONG ROAD TO HOLTVILLE.

Sunset Springs, 4.5 miles southwest of, west side of main canal No. 5, at north side of headgate to Oak canal; iron post stamped "—53 Y"	—51.759

HOLTVILLE, EAST ACROSS COUNTRY TO 2.5 MILES EAST OF HARDY TRIANGULATION STATION; THENCE TO SUNSET SPRINGS.

Holtville, 6.1 miles east of, at old beach rim; iron post stamped "57 Y"	57.792

	Feet.
Holtville, 10 miles northeast of; iron post stamped "79 Y"	79.829
Holtville, 13 miles northeast of, east of low sand ridge; iron post stamped "112 Y"	112.834
Hardy triangulation station, 2.5 miles west of, on summit of hill; iron post stamped "140 Y"	140.913
Hardy triangulation station, 6 miles northwest of; iron post stamped "100 Y"	100.951
Sunset triangulation station, 4 miles east of, 1 mile northeast of Deer Park; iron post stamped "76 Y"	77.010
Sunset triangulation station, on summit; iron post stamped "97 Y"	97.875
Sunset Springs, 10 feet west of; iron post stamped "—44 Y"	—42.719

INTERNATIONAL BOUNDARY MONUMENT NO. 215, ACROSS COUNTRY, TO 2.5 MILES WEST OF HARDY TRIANGULATION STATION.

	Feet.
Boundary monument No. 215, 4.5 miles northeast of; iron post stamped "131 Y"	131.843
Boundary monument No. 215, 8 miles northeast of; iron post stamped "132 Y"	132.809
Boundary monument No. 215, 11 miles northeast of; iron post stamped "128 Y"	128.796
Boundary monument No. 215, 14.3 miles northeast of, 0.75 mile south of Hardy triangulation station, west edge of sand; iron post stamped "132 Y"	132.714

INTERNATIONAL BOUNDARY MONUMENT NO. 217, ACROSS MESA AND ALONG ROAD, TO HOLTVILLE.

	Feet.
Holt and Hickory canals 50 feet south of junction, south of road west of Holt canal, northeast corner of wire fence; iron post stamped "14 Y"	15.216

SUNSET SPRINGS, WEST TO J. W. HART'S RESIDENCE AND RETURN.

	Feet.
Residence of J. W. Hart, 150 feet south of, 15 feet north of check in Orchard canal; iron post stamped "—123 Y"	—121.705

CAMPO, CUYAMACA, JAMUL, LA JOLLA, AND SAN DIEGO QUADRANGLES.

SAN DIEGO COUNTY.

The elevations in the following list are based upon a bronze tablet in the foundation pier, north of the southeast corner of east wing of the San Diego County court-house, 4 feet above ground, stamped "S D". The elevation of this is now accepted as 42.342 feet above mean sea level as obtained by United States Coast and Geodetic Survey precise leveling of 1906 from Point Loma, which recovered also other bench marks of this list at American Park, Linda Vista, and Sorrento.

The double-rodded line Green Valley to San Diego, on La Jolla and San Diego quadrangles, was run in 1898 by Mr. George H. Herrold, levelman; other work on these two quadrangles was done in 1901 under Mr. J. E. Rockhold, topographer, by Mr. W. V. Hardy, levelman, and also on San Diego quadrangle in 1902 under Mr. E. T.

Perkins by Mr. C. L. Nelson. The leveling on Cuyamaca quadrangle was done under Mr. E. T. Perkins in 1901–2, by Mr. Hardy, and in 1902 by Mr. Nelson.

STANDARD BENCH MARKS OF THE UNITED STATES COAST AND GEODETIC SURVEY ON SAN DIEGO AND LA JOLLA QUADRANGLES.

SAN DIEGO QUADRANGLE.

	Feet.
San Diego, tidal 7, directly over tidal 6, in the surface of a cement collar or encasement built around the pile as a protection against destructive sea life, toward the northwest corner of the cement; three-fourths-inch hole 2 inches deep filled with babbitt metal (a rod held upon this point clears the north side of the pier)	1.959
San Diego, tidal 3, in the United States Quarantine Grounds, near the inner end of the pier and southwest of the blacksmith shop, at center of the top of a cement monument, 1 foot square and 2 feet long, projecting 1 foot above the ground, resting upon a pier built of rock and cement upon the sand, 3 feet deep, 2.5 by 4 feet at the bottom, and 2 by 1.5 feet at the top; monument mark "U. S. C. S. 1906" and two diagonal lines, with a light dot at the center	6.167
San Diego, tidal 2, near the northeast corner of the residence of the quarantine surgeon, on the cover of a sewer, in a granite slab 4 feet square, resting on a brick foundation and having an iron-covered manhole 2 feet in diameter in its center; drill hole filled with lead (3½ inches from the edge of the iron cover and northwest of the center of the manhole)	10.086
San Diego, tidal 5, in the United States Quarantine Grounds, near the southeast corner of the Cottage Hospital, on the cover of a sewer, a granite slab 4 feet square, cemented upon masonry and having an iron manhole 2 feet in diameter in its center; three-fourths-inch hole 2 inches deep, filled with babbitt metal flush with the surface (6.5 inches from the manhole, on the southeast corner)	7.780
San Diego, tidal 4, outside the United States Quarantine Grounds, near the northwest corner, about 110 feet north of the fence; cement pier or monument similar to tidal 3 (the soil at the depth of 3 feet and for about a foot above is almost a hardpan)	12.486
San Diego, tidal 1, about 400 feet almost due north of the northwest corner of the United States Quarantine Grounds; center of the top of a granite block 10 inches square	8.721
A. About 1.25 miles north of Roseville, Point Loma, set in hardpan, at the inside corner of the public road leading from Roseville to Old Town, in range with the telephone poles and 1 meter south of the pole set in the corner; Coast Survey iron B. M. post	33.319
B. About 1¾ miles north of San Diego, on the Atchison, Topeka and Santa Fe Railway right of way, about 50 meters north of milepost 266, on west end of concrete culvert "C 266" in the corner of the horizontal surface, 2½ meters below the rail; Coast Survey B. M. tablet	20.622
C. San Diego, at southwest corner of Fir and California streets, on the Atchison, Topeka and Santa Fe Railway right of way, 3 meters west of track, on west side of iron rim to a manhole; surface within an outlined square 1 inch on each side	23.560

LA JOLLA QUADRANGLE.

	Feet.
D. Old Town, about 100 meters east of the Atchison, Topeka and Santa Fe Railway, set in hardpan, in the southwest corner of the public school grounds; stone post 4 feet long by 6 inches square, projecting 6 inches above ground, with a hole cut in top 2.5 centimeters square and about 4 millimeters deep, bottom of which is B. M. (top of post lettered "U. S. B. M.")	25.428
E. About 1 mile north of Atwood, on the Atchison, Topeka and Santa Fe Railway right of way, at west end of concrete culvert F 260, in center of the horizontal surface; three-eighths-inch copper bolt 2 inches long, set (in lead or cement) flush with surface	62.942
F. About 1.25 miles northwest of Ladrillo, 25 meters northwest of milepost 258, set in clay, in the corner of a fence, one-third meter east of the Atchison, Topeka and Santa Fe Railway right of way; iron post, same as "A"	97.038
G. Selwyn, on the Atchison, Topeka and Santa Fe right of way, about 80 meters west of signboard "Selwyn," 16 meters north of track; stone post, same as "D"	232.428
H. Sorrento, about 75 meters southwest of the Atchison, Topeka and Santa Fe Railway station, in the corner of the fence, on land owned by John Works; stone post, same as "D"	40.422
I. About 1 mile south of Del Mar, on the Atchison, Topeka and Santa Fe right of way, 1 meter south of the second telegraph pole south of the road crossing, 15 meters east of the track and set in sand 3 meters above rail; iron post, same as "A"	151.995
J. Del Mar, on West Tenth street, about 100 meters west of the Atchison, Topeka and Santa Fe right of way, on land owned by J. W. Bennett, on the east face of the old cement foundation in center of the vertical surface, three-fourths meter above ground; copper bolt, same as "E"	90.533

STANDARD BENCH MARKS OF THE UNITED STATES GEOLOGICAL SURVEY.

LA JOLLA QUADRANGLE.

GREEN VALLEY, SOUTH ALONG ROAD, TO POWAY DIVIDE; THENCE SOUTHWEST, VIA LINDA VISTA MESA AND MURRAY CANYON, TO NORTH (OLD TOWN) SAN DIEGO (DOUBLE-RODDED LINE).

Watson's ranch, 5 feet east of fence corner, north side of Powey road, at junction with San Diego road; iron post stamped "585"	585.941
Merton post-office, southeast corner of junction of Poway and San Diego road; iron post stamped "438"	438.890
Poway divide, on south side of road; iron post stamped "967"	967.900
Virginia post-office, 0.75 mile southwest of, in forks of road where road down valley leaves San Diego road; iron post stamped "578"	578.897
Linda Vista Mesa, junction of Escondido and Linda Vista road, 8.5 miles north of San Diego; iron post stamped "417"	417.393
Linda Vista Mesa, head of grade out of Mission Valley, on east side of Escondido road and south end of mesa road; iron post stamped "394"	394.357
County Hospital, north of, west side of road to San Diego and 40 feet south of road to Old Town; iron post stamped "28"	28.378

	Feet.
Old Town (San Diego), south and east of motor track, in west wall at northwest corner of brick building, 2.6 feet above porch floor; copper bolt stamped "U. S. G. S. 44 ft. B. M."	44.335

SAN DIEGO COUNTY HOSPITAL, ALONG COUNTY ROAD, TO MORENA; THENCE ALONG SAN DIEGO, PACIFIC BEACH AND LA JOLLA RAILWAY TO RACE TRACK; THENCE ALONG SOUTHERN CALIFORNIA RAILWAY TO SORRENTO.

Moreno, in front of station; top of rail	15.6
Race Track, southwest corner of station; top of rail	21.0
American Park race track, 710 feet north of station, at southwest angle of junction of road to Pacific Beach; iron post stamped "25 S D" (recovered by U. S. Coast and Geodetic Survey)	25.433
Ladrillo, 2 miles north of, 600 feet west of G. N. Gilbert's ranch house; at junction of road to house with road from San Diego to Sorrento; iron post stamped "176 S D"	176.640
Selwyn, at signboard; top of rail	236.3
Linda Vista, 25 feet west of section house, 10 feet east of siding, in northwest corner of yard; iron post stamped "376 S D" (recovered by U. S. Coast and Geodetic Survey)	376.706

LINDA VISTA, EAST ALONG WAGON ROAD TO VIRGINIA.

Linda Vista, 2.4 miles east of, at northwest angle of intersection of roads; iron post stamped "452 S D"	452.895

SORRENTO, EAST ALONG COUNTY ROAD, TO MERTON.

Sorrento, in front of station; top of rail	31.8
Sorrento, 35 feet north of station, 15 feet northwest of section house, 25 feet east of road crossing; iron post stamped "31 S D" (recovered by U. S. Coast and Geodetic Survey)	31.611
Los Perasquitos ranch house, 0.7 mile east of, at intersection of roads; iron post stamped "245 S D"	245.743

SORRENTO, NORTH 1.5 MILES ALONG SOUTHERN CALIFORNIA RAILWAY; THENCE BY WAGON ROAD, VIA SAN DIEGUITO SCHOOLHOUSE, TO LOS PERASQUITOS RANCH.

San Dieguito schoolhouse, 2 feet west of, 1 foot south of porch, at entrance; iron post stamped "53 S D"	53.606
San Dieguito schoolhouse, 4.3 miles east of, at junction of roads; iron post stamped "348 S D"	348.742

SAN DIEGO COUNTY HOSPITAL, VIA COUNTY ROAD UP SAN DIEGO RIVER, TO OLD MISSION DAM; THENCE SOUTH TO LA MESA.

Grantville, at entrance to schoolhouse, on west side of porch; iron post stamped "123 S D"	123.456
Old Mission dam, 125 feet southeast of, 100 feet south of San Diego River, 70 feet north of road, 35 feet east of windmill; iron post stamped "288 S D"	288.513
La Mesa Springs, at northeast corner of La Mesa Lemon Company's store, in brick front, 2.5 feet above porch floor; bronze tablet stamped "539 S D"	540.061

LA MESA SPRINGS, WEST ALONG COUNTY ROAD VIA SAN DIEGO NORMAL SCHOOL, TO SAN DIEGO.

	Feet.
San Diego Normal School, at east side of main entrance, in south face of baluster, set flush with vertical surface 3 feet above ground; bronze tablet stamped "355 S D"	356.024

SAN DIEGO QUADRANGLE.

QUARANTINE STATION, NORTHEAST TO NORTH SAN DIEGO (OLD TOWN); THENCE SOUTH ALONG PACIFIC BEACH MOTOR TRACK TO SAN DIEGO (DOUBLE-RODDED LINE).

Quarantine station, north of, on Point Loma, U. S. Coast and Geodetic Survey bench mark, "Tidal 1," granite block 10 inches square on top, marked "U. S." (north side marked "Ref. Mark," east side marked "Coast Survey," south side marked "1853-54-55," north side marked "for tide," latest value)	8.721
Roseville, at southeast corner of fenced school grounds; iron post stamped "35" (recovered by U. S. Coast and Geodetic Survey)	35.295
San Diego County court-house, in the foundation pier north of southeast corner of east wing, 4 feet above ground; bronze tablet stamped "42 S D"	42.342
San Diego, City B. M., City Hall Building, corner Third and D streets; north corner of stone steps[a] (recovered by U. S. Coast and Geodetic Survey)	46.119
San Diego, in brick wall of west front of Creigne Building, 2 feet above step north of door, corner of Fourth and K streets; old U. S. Coast and Geodetic Survey bench mark, Geological Survey elevation	12.20

SAN DIEGO COURT-HOUSE, VIA NATIONAL CITY AND OTAY RAILWAY, TO OTAY.

San Diego, intersection of Front street and Southern California Railway track; top of rail	8.0
San Diego, at crossing of the National City and Otay and the San Diego, Cuyamaca and Eastern railways; top of rail	9.7
National City, at intersection of National avenue and First street; top of rail	27.0
National City, at Twenty-fifth street, 60 feet north of school, east of road; iron post stamped "57 S D"	57.832
Sweetwater Junction; top of rail	23.5
Chulavista, in front of station; top of rail	74.2
Otay, 1.5 miles south of schoolhouse, 1 foot east of porch, at east side of entrance; iron post stamped "62 S D"	62.572

SWEETWATER JUNCTION, VIA NATIONAL CITY AND OTAY RAILWAY, TO LA PRESA; THENCE NORTH TO LA MESA.

Bonita store, in front of platform; top of rail	60.3
Sweetwater schoolhouse, 85 feet northwest of, 25 feet south of road and 15 feet south-southeast of pepper tree; iron post stamped "65 S D"	65.554
Sunnyside, in front of station; top of rail	93.5
Aloha, in front of station; top of rail	152.2
La Presa, 1 mile southwest of, 130 feet northeast of signboard at intersection of roads; iron post stamped "238 S D"	238.566

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[a] The elevation of this bench mark by the city datum is 40 feet.

OTAY, ALONG COUNTY ROAD EAST, TO WEST LINE OF OTAY RANCH.

	Feet.
T. 18 S., R. 1 W., sec. 20, 3 feet north of east gate to Dr. Wiard's field, 2 feet east of west line to Otay ranch, 10 feet northwest of intersection of roads; iron post stamped "149 S D"	149.515

JAMUL 15′ (CUYAMACA 30′) QUADRANGLE.

WEST LINE OF OTAY RANCH, NORTHEAST TO JAMUL RANCH.

Lower Otay dam, 33 feet southeast of east end of sec. 18, T. 18 S., R. 1 E., 70 feet east of intersection of filled road with dam, on northwest face of bowlder 4 by 3 by 2 feet; bronze tablet stamped "486 S D"	486.569
T. 18 S., R. 1 E., sec. 4, 300 feet northwest of Jones's house, 50 feet northeast of intersection of roads, on top of bowlder 3 by 3 by 1.5 feet; bronze tablet stamped "514 S D"	514.887

JAMUL RANCH, ALONG COUNTY ROAD NORTH, TO JAMUL POST-OFFICE; THENCE WEST TO LA PRESA.

Jamul, 231 feet northeast of schoolhouse, 3 feet east of southeast corner of Barrett's property, 25 feet northeast of intersection of roads, on top of bowlder 2.5 by 2 by 1 foot; bronze tablet stamped "1040 S D"	1,040.274
T. 16 S., R. 1 W., on San Bernardino meridian, 2 feet south of northeast corner sec. 36, 400 feet north of Sweetwater River, about 1 mile northeast of forks of road to La Presa and Jamul; iron post stamped "342 S D"	342.413

JAMUL RANCH, EAST ALONG COUNTY ROAD 3.5 MILES, TO LYON PEAK ROAD.

Intersection of Jamul and Lyon Peak road with road branching to Lawson Valley, 35 feet northwest of, on south face of bowlder 9 by 9 by 9 feet, 4 feet above ground; bronze tablet stamped "1400 S D"	1,400.549

FORKS OF ROAD 3.5 MILES EAST OF JAMUL RANCH, NORTHWEST VIA COUNTY ROAD, TO DIVIDE BETWEEN WOOD VALLEY AND LEE VALLEY.

Jamul, 3.5 miles east of, T. 16 S., R. 2 E., near southwest corner of section 31, on ridge divide between Wood and Lee valleys, at intersection of Lyons and Lawson Valley roads, 8 feet northeast of oak tree; iron post stamped "1789 S D"	1,789.549

JAMUL RANCH, SOUTHEAST ALONG COUNTY ROAD, TO DALZURA.

Dalzura schoolhouse, 120 feet south of, 6 feet north of creek ford, 6 feet north of road, on top of granite bowlder; bronze tablet stamped "1243 S D"	1,243.680

CUYAMACA QUADRANGLE.

EAST OF JAMUL RANCH, EAST ALONG COUNTY ROAD, TO MORENA DAM; THENCE SOUTH TO CAMPO.

Pine Valley station, 2.5 miles west of, sec. 5, T. 17 S., R. 3 E., 500 feet southeast of old adobe building, 15 feet north of road at summit, in top of granite bowlder; bronze tablet stamped "2108 S D"	2,110.642
Morena dam, 0.4 mile north of sec. 14, T. 17 S., R. 4 E., near quarter corner, 170 feet east of road; iron post stamped "3010 S D"	3,010.134

DALZURA, SOUTHEAST ALONG COUNTY ROAD, TO CAMPO.

	Feet.
Eisenecke, sec. 8, T. 18 S., R. 3 E., 81 feet west of Barnight's house, 36 feet north of barn, 27 feet north of road, in granite bowlder, 1 foot above ground; bronze tablet stamped "875 S D"	875.539
Potrero, 300 feet west of post-office, sec. 18, T. 18 S., R. 4 E., at intersection of roads, 0.7 foot below top of bowlder 4 feet high; iron post stamped "2323 S D"	2,323.478
T. 18 S., R. 4 E., sec. 24, at first crossing of Campo Creek, 200 feet west of ford, 3 feet north of road, 100 feet east of turn, on south face of bowlder 10 by 7 by 8 feet; bronze tablet stamped "2189 S D"	2,189.483

FORK OF ROAD, 2.5 MILES NORTHWEST OF PINE VALLEY STATION, NORTH ALONG COUNTY ROAD, TO DESCANSO; THENCE SOUTHEAST, VIA PINE VALLEY POST-OFFICE, TO MORENA DAM.

	Feet.
Japatul schoolhouse, 12 feet southeast of, sec. 15, T. 16 S., R. 3 E., in top of granite bowlder 2.5 by 2.5 by 2 feet; bronze tablet stamped "2866 S D"	2,866.166
Descanso, 1.5 miles east of, 2 feet south of signpost, on west side of road, at junction of road to Campo; iron post stamped "3541 S D"[a]	3,541.126

PINE VALLEY POST-OFFICE, SOUTHWEST ALONG COUNTY ROAD, TO CORTE MADARA.

	Feet.
Corte Madara ranch house, 85 feet north of, sec. 21, T. 16 S., R. 4 E.; in top of granite bowlder 6 by 6 by 1.5 feet; bronze tablet stamped "3965 S D"	3,965.135

DESCANSO, ALONG WAGON ROAD NORTHWEST, TO SUMMIT EAST OF VIEJAS VALLEY.

	Feet.
T. 15 S., R. 3 E., sec. 14, 3 miles west of Descanso, 16 feet southeast of road on summit east of Viejas Valley, in top of granite bowlder 3 by 3 by 1.5 feet; bronze tablet stamped "3672 S D"	3,672.448

FORKS OF ROAD, 1.5 MILES EAST OF DESCANSO, NORTH ALONG COUNTY ROAD VIA CUYAMACA, TO JULIAN.[b]

	Feet.
Twin Pine Springs, 1.4 miles south of, 10 feet east of road, at junction of road running east to Mr. Hobb's house; iron post stamped "4132 S D"	4,132.421

CAMPO QUADRANGLE.

AT CAMPO.

	Feet.
Campo, 30 feet west of custom-house, 100 feet southeast of store, on vertical face of bowlder 15 by 30 by 20 feet, 3 feet above ground; bronze tablet stamped "2543 S D"	2,543.511

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[a] No standard bench marks were left on remainder of this line.

[b] This line, rerun as far as Cuyamaca, still closes 1.6 feet high on accepted height of Julian in the list on Ramona quadrangle.

CAPISTRANO, CLARK LAKE, CORONA, ELSINORE, ESCONDIDO, INDIO SPECIAL, OCEANSIDE, RAMONA, RIVERSIDE, SALTON, SAN JACINTO, AND SAN LUIS REY QUADRANGLES.

ORANGE, RIVERSIDE, AND SAN DIEGO COUNTIES.

The elevations in the following list are based upon the precise-level line run by the United States Coast and Geodetic Survey in 1906 along the Atchison, Topeka and Santa Fe Railroad from Point Loma (near San Diego), which recovered many bench marks of this list. They are also corrected in agreement with a checked primary-level line run by Mr. R. A. Farmer, topographer, east along the Southern Pacific Railroad from Colton to Montmere, checked throughout within primary limits by comparison with a former double-rodded line of 1898 by Mr. George H. Herrold, Colton to Palm Springs, and by a single line of 1901, thence to Montmere, by Mr. C. C. Ward, a third running being made when necessary.

Leveling on Capistrano and Corona quadrangles was done in 1899 under Mr. L. C. Fletcher, topographer; on Escondido, Oceanside, San Luis Rey, and south edge of Elsinore quadrangles in 1899 under Mr. W. T. Turner, topographer, on Ramona quadrangle in 1900; and on Clark Lake, Indio Special, and Salton quadrangles in 1901, by Mr. Ward, levelman. Leveling was also done on Corona, Elsinore, Riverside, and San Jacinto quadrangles in 1897 and 1898 and a double-rodded line on Escondido and San Luis Rey quadrangles in 1898 by Mr. Herrold, levelman, and on Corona quadrangle in 1899 by Mr. C. R. Smith, levelman.

A portion of these bench marks are stamped "S B," referring to San Bernardino, but the elevation now accepted there is 0.7 greater than the elevation previously published.

STANDARD BENCH MARKS OF THE UNITED STATES COAST AND GEODETIC SURVEY ALONG THE ATCHISON, TOPEKA AND SANTA FE RAILWAY.

OCEANSIDE QUADRANGLE (SAN LUIS REY 30′ QUADRANGLE).

	Feet.
K. About 1.25 miles southeast of Encinitas, on the Atchison, Topeka and Santa Fe right of way, at the southwest end of the concrete culvert A 240, in the center of the horizontal surface of the coping; copper bolt	72.734
L. Encinitas, 0.25 mile west of the Atchison, Topeka and Santa Fe Railway station, at the corner of Third and E streets, in the public school grounds, in the middle of the front yard, about 35 meters east of the schoolhouse; iron pipe, set in cement. (U. S. C. & G. S. B. M. post)	91.942
M. About 0.66 mile southeast of Carlsbad, 1 telegraph pole northwest of milepost 230, at the east corner of the road crossing, on the public highway, at the intersection of the Atchison, Topeka and Santa Fe right of way and the cattle-yard fences; bottom of a hole 2.5 cm. square and about 4 mm. deep, cut in top of a stone post whose top is 6 inches square, projecting 6 inches above ground, and lettered "U. S. B. M"	44.156

	Feet.
N. Carlsbad, about 175 meters southwest of the Atchison, Topeka and Santa Fe Railway station, in the park owned by the Huntington Syndicate Company, at the east corner of the most northerly house, at the south end of the first concrete basement step; copper bolt, same as "K"	55.492
O. Oceanside, about 60 meters south of the Atchison, Topeka and Santa Fe Railway station, on railroad property, about 10 meters southwest of the track, and one-third meter outside of the fence; stone post with hole, same as "M"	44.420
P. Oceanside, on the south corner of First and Ditmar streets, in the northeast side of the First Methodist Episcopal Church, 0.66 meter from north corner and 1 meter above ground; copper bolt, same as "K"	83.805
Q. Oceanside, at the west corner of Second and Hill streets, on the step of the side entrance to the Bank of Oceanside Building; surface of an outlined square 1 inch on each side, unlettered	67.627
R. Oceanside, on the northwest side of Third street, between Tremont and Hill streets, in the brick store, 2½ blocks northeast of the Atchison, Topeka and Santa Fe Railway; Coast Survey B. M. tablet	64.438

SAN LUIS REY 30' QUADRANGLE.

S. About 0.66 mile southeast of Las Flores, on the Atchison, Topeka and Santa Fe right of way, 9½ telegraph poles southeast of milepost 219, 12 meters southwest of track; iron pipe set in clay, same as "L"	74.952
T. About one-third mile southeast of Las Flores, on the Atchison, Topeka and Santa Fe right of way, 1½ telegraph poles southeast of milepost 219, at the southwest end of concrete culvert A 220, in horizontal surface of coping, one-third meter from northwest corner, 3 meters below rail; copper bolt, same as "K"	58.324
U. Don, about 45 meters west of signboard "Don," between the Atchison, Topeka and Santa Fe right-of-way fence and the first telephone pole northwest of the warehouse; stone post with hole, same as "M"	136.736

CAPISTRANO QUADRANGLE.

V. Four-tenths mile west of San Onofre, about 150 meters west of the county road crossing, on the north side of the county road, one-third meter south of the Atchison, Topeka and Santa Fe right of way; stone post with hole, same as "M"	9.985
W. One-third mile northwest of Mateo, about 75 meters east of the Atchison, Topeka and Santa Fe Railway, 3 meters north of the county road, and 4 meters west of the bridge, near the corner of a fence; iron pipe, same as "L"	15.117
X. Two-thirds mile north of Serra, opposite the second telegraph pole southwest of milepost 199, one-half meter southeast of the Atchison, Topeka and Santa Fe right of way, in corner of a fence, at foot of a hill; iron pipe, same as "L"	41.252
Y. San Juan Capistrano, northeast of the Capistrano mission, in the southwest corner of the public school grounds; post	120.762

CORONA 30′ QUADRANGLE.

	Feet.
Z. San Juan Capistrano, 0.25 mile north of the Atchison, Topeka and Santa Fe Railway station, on the right of way, about 100 meters north of milepost 197, at the east end of a large concrete culvert, on the horizontal surface of the coping, one-third meter from north end; tablet, same as "R"	115.741
A_1. About 4⅓ miles south of El Toro, on the Atchison, Topeka and Santa Fe right of way, 1 telegraph pole north of the road crossing. at the west end of concrete culvert A 193, on the center of the horizontal surface of the coping; surface of a square 1 inch on each side, marked "U. S."	279.973
B_1. About 1½ miles southeast of Irvine, opposite half-mile pole 194½, at the corner of the public road, one-third meter north of the Atchison, Topeka and Santa Fe right of way; stone post with hole, same as "M"	258.079
C_1. Irvine, 40 meters south of the Atchison, Topeka and Santa Fe Railway station, in the north corner of the public school grounds; stone post with hole, same as "M"	193.913
D_1. One-half mile south of Aliso, on the public highway, at the southwest corner of the road crossing near milepost 178; iron pipe, same as "L"	81.256
E_1. Santa Ana, about 1½ miles southeast of the Atchison, Topeka and Santa Fe Railway station, 3½ telegraph poles west of milepost 177, at road crossing, on the south side of the track, in the horizontal surface of the irrigation culvert; copper bolt, same as "K"	105.661
F_1. Santa Ana, one-third mile south of the Atchison, Topeka and Santa Fe Railway station, on the north side of Chestnut street, between the Southern Pacific Railway and the Atchison, Topeka and Santa Fe Railway; highest point of star on top of hydrant	122.972
City, Santa Ana, on the northwest corner of Third and Garfield streets; copper wire set in center of a cement block	128.023
G_1. Santa Ana, on the northwest corner of the City Hall, in water table, facing Third street, 1¼ meters above the walk; tablet, same as "R"	124.144
H_1. Santa Ana, at the main entrance to the court-house, on the southeast corner of the east granite balustrade, 1 meter above the walk; 1 inch square, same as "Q"	133.341
I_1. Orange, in the center of the west side of the plaza, 5 meters east of the west fence; iron pipe, set in cement, same as "L"	187.024
J_1. Orange, in the Orange Union High School Building, at the north side of the main entrance, in the vertical surface of the concrete water table, one-third meter above the balustrade; tablet, same as "R"	197.497
K_1. About 1¼ miles north of Orange, about 45 meters north of milepost 46, in the southeast corner of road crossing, on land of N. T. Edwards; stone post with hole, same as "M"	188.466
L_1. Olive, about 225 meters northeast of the Atchison, Topeka and Santa Fe Railway station, in the public school grounds, in the angle formed by the west side of the front entrance and the main building, set in gravel; iron pipe, same as "L"	274.166

	Feet.
M_1. About seven-eighths mile north of Olive, on the Atchison, Topeka and Santa Fe right of way, about 165 meters south of milepost 43, at the northeast corner of the plate girder bridge A 44, on the northeast corner of the steel base, about two-thirds meter below the rail; outlined square, in iron, same as "Q"	241.070
N_1. Richfield, about 40 meters north of the railroad station, in northwest corner of highway junction, on range with telephone poles; stone post with hole, same as "M"	246.365
O_1. Horse Shoe Bend, 1½ telegraph poles southwest of signboard "Horse Shoe Bend," at the road crossing, 8 meters south of small highway bridge, on the sloping surface of the concrete canal; tablet, same as "R"	381.781
P_1. About 1⅓ miles west of Gypsum, on the Atchison, Topeka and Santa Fe right of way, at north end of county culvert C 35, on horizontal surface of coping, one-third meter from east end; copper bolt, lettered "U. S."	401.920
Q_1. About 1 mile southwest of Crary, on the Atchison, Topeka and Santa Fe right of way, 23 meters south of milepost 29, 14 meters west of track, on north slope of small knoll; iron pipe, same as "L"	469.960
R_1. About two-thirds mile northeast of Crary, on the Atchison, Topeka and Santa Fe right of way, at the northwest corner of the road crossing; stone post with hole, same as "M"	507.120
S_1. Corona, directly south of the Atchison, Topeka and Santa Fe railway station, in center of the triangular park belonging to the railroad company; iron pipe, same as "L"	606.256
T_1. Corona, on the west side of Main street, in the northeast corner of Masonic Block, one-half meter from the east face and 1⅓ meters above the walk; copper bolt, same as "K"	685.455
City. Corona, at the northwest corner of Main and Sixth streets, 2 meters northeast of the main entrance to the Citizens' Bank; a metal plug set in the cement walk, corresponds to 171.20 feet, city datum	673.761
U_1. Within the city limits, Riverside, 1 telegraph pole southwest of signboard "Alvord," in the easterly corner of the road crossing, on land owned by J. T. Hammer; iron pipe, same as "L"	669.348

RIVERSIDE 15′ QUADRANGLE (ELSINORE 30′ QUADRANGLE).

V_1. Within the city limits, Riverside, about 2.75 miles southwest of Arlington, at the southernmost corner of the road crossing, at milepost 19, 1 meter northwest of telegraph pole; stone post with hole, same as "M"	720.346
W_1. Within the city limits, Riverside, one-half mile northeast of Arlington, 4 telegraph poles northeast of milepost 16, in the northwest corner of road crossing, on land owned by R. L. Carpenter; stone post with hole, same as "M"	846.068
X_1. Within the city limits, Riverside, about 1 mile southwest of Casa Blanca, on the Atchison, Topeka and Santa Fe right of way, 2½ telegraph poles northeast of milepost 15, on northwest side of northeast concrete abutment of trestle D 15, on the horizontal surface, at the angle; outlined square, same as "Q"	847.502

	Feet.
Y_1. Riverside, on the north side of the county court-house, 2 meters west of northeast corner, in the center of small projection, one-third meter above ground; copper bolt, same as "K"	847.944
Z_1. Riverside, at the east side of the main entrance to the Carnegie Public Library, on the horizontal surface of the cement balustrade, one-third meter from building; tablet, same as "R"	857.405

STANDARD BENCH MARKS BY THE UNITED STATES GEOLOGICAL SURVEY.

CORONA QUADRANGLE.

MAGNOLIA CROSSING, SOUTHWEST ALONG MAGNOLIA AVENUE AND NORTHWEST ALONG HIGHWAY, TO RINCON; THENCE SOUTHWEST, ALONG ROAD, TO OLIVE.

May, 0.25 mile southwest of signboard (within city limits of Riverside), on Magnolia avenue, 250 feet northeast of crossing, in line with center row of trees; iron post stamped "687" (recovered by U. S. Coast and Geodetic Survey)	687.776
Corona, at northwest corner of Buena Vista avenue and Limon street (pipe line No. 2); iron post stamped "1049 S B"	1,050.291
Crary (Rincon post-office), on north side of street, at southeast corner of post-office and store; iron post stamped "494 S B" (recovered by U. S. Coast and Geodetic Survey)	494.559
Rincon, 7.3 miles west of, at head of grade where road finally leaves the sidehill slopes of Santa Ana Canyon, on north side of road; iron post stamped "402 S B"	402.576

OLIVE, SOUTHEAST UP SANTIAGO CREEK ROAD, TO DIVIDE; THENCE SOUTHWEST, DOWN ALISO CREEK, TO EL TORO.

Olive, 7.7 miles southeast of, at northeast corner of fence of Orange County Park, 20 feet to the right of road; iron post stamped "610 S B"	610.931
Olive, 13.7 miles southeast of, where road to Silverado turns off to east up side of gulch, 8 feet west of main road; iron post stamped "977 S B"	978.246
Olive, 17 miles southeast of, along Santiago Creek where Santiago Canyon road begins to climb sidehill to cross divide into Aliso Canyon, en route to El Toro; iron post stamped "1271 S B"	1,271.473
Aliso schoolhouse, about 45 feet from, in northwest corner of yard; iron post stamped "1041 S B"	1,041.808

EL TORO, SOUTH ALONG SOUTHERN CALIFORNIA RAILROAD, TO CAPISTRANO.

El Toro schoolhouse, 2 feet from front of, in angle formed by porch and building; iron post stamped "444 S B" (recovered by U. S. Coast and Geodetic Survey)	444.862
El Toro, 4.33 miles south of, 40 feet east of track, at road crossing, in fence corner; iron post stamped "278 S B"	279.093

TEMESCAL, NORTHWEST ALONG ROAD, TO CORONA.

Rugby district school, north side of sec. 21, T. 4 S., R. 6 W., northeast corner of grounds; iron post stamped "897"	898.000
Corona, southeast angle of, Porphyry quarry and Corona road; iron post stamped "903"	904.077

RINCON, NORTH ALONG ROAD, TO DEL CHINO; THENCE EAST TO LA SIERRA RANCH; THENCE SOUTH TO CORONA.

	Feet.
Chino rancho, where Central avenue crosses road running east and west, in northwest angle of road, 1.5 miles south of Southern Pacific station at Chino; iron post stamped "633 S B"	633.481
Chino rancho, at southeast corner of boundary; iron post stamped "602 S B"	603.269
La Sierra rancho (Sepulveda), 1 mile south of Cooks Ford, east side of road from Corona; iron post stamped "683 S B"	684.083

ESPERANZA SIDING, NORTHERLY VIA WAGON ROAD, TO SAN JUAN TRIANGULATION STATION.

San Juan triangulation station, in top of stone and cement monument; aluminum tablet stamped "1780 S B"	1,781.064

CAPISTRANO, NORTHEAST UP SAN JUAN CANYON.

Capistrano, 2 miles east of, 320 feet east of southwest corner sec. 32, T. 7 S., R. 7 W., north side of road; iron post stamped "149 S B"	149.898

CAPISTRANO QUADRANGLE.

CAPISTRANO, SOUTHEAST ALONG SOUTHERN CALIFORNIA RAILROAD, TO LA FLORES.

Capistrano, in northwest corner of flower plot south of station and east of track; iron post stamped "103 S B" (recovered by U. S. Coast and Geodetic Survey)	103.919
San Onofre siding, 20 feet front of section bunk house, in yard; iron post stamped "28 S B" (recovered by U. S. Coast and Geodetic Survey)	28.666
Don (formerly Jerome), 2.4 miles northwest of, 50 feet east of track, in fence corner on south side of cattle crossing; iron post stamped "165 S B" (recovered by U. S. Coast and Geodetic Survey)	165.671

RIVERSIDE 15′ QUADRANGLE (ELSINORE 30′ QUADRANGLE).

RIVERSIDE, SOUTHWEST ALONG SOUTHERN CALIFORNIA RAILWAY, TO MAGNOLIA AVENUE CROSSING.

Riverside, in alcove on right of main entrance to Loving Opera House, 4 feet above sidewalk, bronze tablet stamped "851" (recovered by U. S. Coast and Geodetic Survey)	851.577
Riverside, in alcove on right of main entrance to Loving Opera House, 1 foot above sidewalk, official city bench mark (elevation of which by city datum, as obtained from city engineers, is 848.777); copper bolt	848.653
Olivewood Cemetery, at canal crossing, 0.5 mile north of Pachapa siding; iron post stamped "863" (recovered by U. S. Coast and Geodetic Survey)	863.387
Casa Blanca, in southeast concrete foundation pier of station platform, 1 foot underground, protected by covered tin cylinder 4 inches high; copper bolt stamped "861" (recovered by U. S. Coast and Geodetic Survey)	861.721
Arlington, center of Southern California Railway station park; iron post stamped "814" (recovered by U. S. Coast and Geodetic Survey)	815.249

RIVERSIDE, EAST TO BOX SPRINGS; THENCE NORTH TO HIGH GROVE.

	Feet.
Riverside, Gage canal at Eighth street, in concrete bulkhead north of bridge; copper bolt stamped "1019"	1,019.821
Box Springs station, near crossing of Box Springs road and railroad, 65 feet west of track, 30 feet west of road; iron post stamped "1539"	1,540.064

BOX SPRINGS, SOUTH ALONG SOUTHERN CALIFORNIA RAILROAD, TO VALVERDE.

Valverde, east wall of brick warehouse, 4.5 feet above ground; copper bolt stamped "1509"	1,509.870

AT TEMESCAL.

Temescal, southwest corner of district school grounds; iron post stamped "1114"	1,114.432

ARLINGTON, SOUTHEAST TO EL SOBRANTE; THENCE EAST TO NEAR VALVERDE.

Mocking Bird Canyon, south of bowlder dam (natural), on Hogback 50 feet south of road; iron post stamped "1219"	1,219.536
El Sobrante, 75 feet northeast of crossing of Gavilan mine and tin-mine roads; iron post stamped "1447"	1,447.823
North Mount Glen, center of sec. 10, T. 4 S., R. 4 W., in northwest corner of school grounds and at southeast corner of crossing of Elsinore and Corona roads; iron posts stamped "1651"	1,652.047

ELSINORE 30′ QUADRANGLE.

VALVERDE, ALONG SOUTHERN CALIFORNIA RAILROAD TO PERRIS; THENCE SOUTHWEST TO ELSINORE.

Perris, Santa Fe station, south wall of brick corridor; bronze tablet stamped "1456"	1,456.697
Canyon siding, 4.5 miles south of Perris, 30 feet north of road where it leaves canyon and crosses over hills to west; iron post stamped "1399"	1,399.860
Menifee road, east of bridge over San Jacinto River and east of railroad track on south side of road; iron post stamped "1318"	1,318.740
Elsinore, Consolidated Bank Building, in brickwork on right side of corner entrance; bronze tablet stamped "1305"	1,305.753

ELSINORE, NORTHWEST ALONG SOUTHERN CALIFORNIA RAILROAD AND HIGHWAY, TO TEMESCAL.

Terra Cotta, 1 mile east of, east of road forks, 3.5 miles northwest of Elsinore; iron post stamped "1258"	1,258.346
T. 5 S., R. 5 W., sec. 7, 3 feet east of quarter-section post of, secs. 7 and 12, north of Temescal road; iron post stamped "1142"	1,143.144

NEAR VALVERDE, EAST TO PERRIS INDIAN SCHOOL.

Perris Indian School, east side of sec. 7, T. 4 S., R. 3 E., in brick balcony south side of steps at southwest entrance to main building; copper bolt stamped "1456"	1,457.173

BOX SPRINGS, EAST ALONG ROAD, TO MORENO; THENCE SOUTH TO LAKE VIEW; THENCE SOUTHWEST, ALONG SOUTHERN CALIFORNIA RAILROAD, TO PERRIS.

Box Springs, north of siding, 65 feet west of Southern California Railway track and 30 feet west of road, at crossing of Box Springs road and railroad; iron post stamped "1539"	1,540.064

	Feet.
Alessandro boulevard and Heacock street, at northeast corner of street, T. 3 S., between Rs. 3 and 4 W.; iron post stamped "1565"	1,565.452
Moreno, in front wall of brick store, southeast corner of streets; bronze tablet stamped "1600"	1,600.596
Lake Bottom road, 50 feet west of, in granite bowlder 2 feet high, 12 by 5 feet, at east point of hill 3 miles north of Lakeview; copper bolt stamped "1430"	1,430.770
Lakeview, northeast angle of lawn, public school grounds; iron post stamped "1468"	1,468.823

LAKEVIEW, SOUTHEAST ALONG ROAD, TO CASA LOMA.

Casa Loma ranch, at northeast fence corner, San Jacinto road and line between Rs. 1 and 2 W., T. 4 S.; iron post stamped "1466"	1,466.594

PERRIS, SOUTHEAST ALONG SOUTHERN CALIFORNIA RAILROAD (SAN JACINTO DIVISION), TO WINCHESTER; THENCE NORTHEAST ALONG SAME TO HEMET.

Benedict school, northeast corner of grounds and northeast corner of sec. 24, T. 5 S., R. 3 W.; iron post stamped "1500"	1,500.436
Winchester, east of front entrance of public school building; bronze tablet stamped "1470"	1,470.6
Egan siding, 1 mile southwest of, on line between Rs. 1 and 2 W., T. 5 S., north line of right of way; iron post stamped "1502"	1,503.249

ELSINORE, SOUTHEAST ALONG SOUTHERN CALIFORNIA RAILROAD, TO TEMECULA.

Wildomar, corner Main street and Murrieta road, in angle of L-shaped schoolhouse grounds; iron post stamped "1254"	1,254.733
Murrieta, in southwest corner of public school grounds; iron post stamped "1092"	1,092.966

TEMECULA, NORTH ALONG ROAD, TO WINCHESTER.

T. 7 S., R. 3 W., near range line east of sec. 13, top of grade; iron post stamped "1309"	1,309.586
Alamos district school grounds, east side sec. 5, T. 7 S., R. 2 W., 35 feet east of building; iron post stamped "1375"	1,376.007
T. 6 S., R. 2 W., sec. 28, 335 feet north of bridge; iron post stamped "1419"	1,419.516
T. 6 S., R. 2 W., northwest corner sec. 10, Domenigoni Valley, 2.5 miles south of Winchester, at southeast corner of fence, road to Hemet; iron post stamped "1458"	1,458.454

SAN JACINTO QUADRANGLE.[a]

SAN JACINTO, SOUTH ALONG SOUTHERN CALIFORNIA RAILWAY, TO HEMET.

San Jacinto, north side of east entrance of public school building; bronze tablet stamped "1562"	1,562.463
Hemet grammar school, in brick column on north side of steps; bronze tablet stamped "1591"	1,591.827

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[a] For additional elevations on this quadrangle refer to Farmer's double-primary line, Colton to Yuma, along Southern Pacific Railway, p. 30.

HEMET, SOUTHEAST ALONG ROAD, TO KENWORTHY.

	Feet.
Vallevista, southwest corner of school grounds; iron post stamped "1765"	1,765.817
T. 5 S., R. 2 E., sec. 18, range line on west side of section, top of knoll 20 feet south of road and east of bridge; iron post stamped "2062"	2,062.771
T. 5 S., R. 2 E., sec. 27, near mouth of Strawberry Creek, 125 feet from east side of road, in granite bowlder; copper bolt stamped "2932"	2,932.732
T. 5 S., R. 2 E., sec. 25, near mouth of Johnson Creek, 170 feet north of bridge, east side of road, inside of angle in fence; iron post stamped "4443"	4,443.802
T. 5 S., R. 3 E., sec. 31, divide of Hemet Valley and San Jacinto drainage, 20 feet north of road; iron post stamped "4936"	4,936.765
T. 6 S., R. 3 E., sec. 10, Thomas's ranch, opposite and north of house, west of road at fence corner, on section line between sections 3 and 10; iron post stamped "4394"	4,394.718
T. 6 S., R. 3 E., sec. 25, Thomas's ranch, 10 feet east of south gate, where road forks to Kenworthy and Coahuila Valley; iron post stamped "4509"	4,509.751

KENWORTHY, SOUTHWEST ALONG ROAD, TO WILSON VALLEY.

	Feet.
Coahuila divide, 18 feet west of road; iron post stamped "4965"	4,965.988
T. 7 S., R. 3 E., sec. 21, Mission Indian Reservation, 20 feet west of north gate, on north side of road; iron post stamped "3836"	3,836.748
Coahuila Indian School, sec. 23, T. 7 S., R. 2 E., 3 feet north of the southwest corner of the chapel yard; iron post stamped "3635"	3,635.696
T. 8 S., R. 2 E., sec. 5, divide between Coahuila and Wilson valleys, 7 feet southeast of road; iron post stamped "3542"	3,543.057

WILSON VALLEY, NORTH ALONG ROAD VIA SAGE, TO HEMET.

	Feet.
T. 7 S., R. 1 E., sec. 20, Lewis Valley, east of road, 18 feet north of line fence between sections 20 and 29; iron post stamped "2130"	2,130.960
Sage post-office, east of, sec. 12, T. 7 S., R. 1 W., on east side of Coahuila road; iron post stamped "2283"	2,283.879
T. 6 S., R. 1 W., sec. 36, Sage divide, 10 feet east of road, 260 paces south of Hemet road; iron post stamped "2615"	2,615.855
T. 6 S., R. 1 W., sec. 4, Diamanta schoolhouse, in Diamond Valley, 0.5 mile west of county road, 20 feet east of entrance to building, in edge of lawn; iron post stamped "1626"	1,626.898

THREE MILES EAST OF BEAUMONT, NORTH TO SOUTHWEST CORNER SAN BERNARDINO FOREST RESERVE (DOUBLE-RODDED LINE).

	Feet.
Ts. 2 and 3 S., Rs. 1 E. and 1 W., common corner, at southwest corner of San Bernardino Forest Reserve, 1.5 miles north of railroad, 2 feet south of Forest Reserve monument, which is an iron pipe filled with concrete on San Bernardino meridian; iron post stamped "2710"	2,710.700

THREE MILES EAST OF BANNING, NORTH TO TOWNSHIP AND RANGE LINE CORNER (DOUBLE-RODDED LINE).

	Feet.
Ts. 2 and 3 S., Rs. 1 and 2 E., common corner, on south line of San Bernardino Forest Reserve, 1.25 miles north of Southern Pacific Railroad, in top of square iron post filled with concrete; copper bolt stamped "2342"	2,342.234

FROM 3.6 MILES EAST OF CABEZON, NORTH TO TOWNSHIP AND RANGE LINE CORNER (DOUBLE-RODDED LINE).

	Feet.
Ts. 2 and 3 S., Rs. 2 and 3 E., common corner, 2 feet north of San Bernardino Forest Reserve, 1.7 miles north of Southern Pacific Railroad; iron post stamped "1978"	1,978.563

WHITEWATER, SOUTHEAST ALONG ROAD, TO PALM SPRINGS; THENCE SOUTH UP PALM CANYON TRAIL, TO VANDEVENTER; THENCE NORTHWEST TO KENWORTHY.

T. 3 S., R. 4 E., sec. 29, 2.5 miles southeast of trestle 584 F, 25 feet east of rocky point, 5 feet south of Rubble canal from Whitewater River to Palm Springs; iron post stamped "828"	828.681
Palm Springs, in south concrete wall hotel building; bronze tablet stamped "455"	455.833
Garden of Eden, on township line between Ts. 4 and 5 S., R. 4 E., east of Palm Canyon road; iron post stamped "557"	557.878
Garden of Eden, 3 miles south of, east side of Palm Canyon, in a grove of palms on southwest side of small canyon, side of trail; iron post stamped "1000"	1,000.720
Garden of Eden, 10 miles south of, in Palm Canyon, near rocky gorge, by west wall of canyon, 100 feet southwest of creek crossing, where trail leaves the main canyon and crosses hills to the east; iron post stamped "3000"	3,000.032
Vandeventer, north of house on a little knoll, in a granite bowlder 3 feet high, 8 by 4 feet, 50 feet east of road to house just south of where it forks to Kenworthy; copper bolt stamped "4549"	4,549.646
Kenworthy, south of post-office, in a granite bowlder 3 feet high, 7 by 5 feet, at rocky point 100 feet north of wash, by trail; bolt stamped "4566"	4,566.491

INDIO SPECIAL QUADRANGLE.[a]

WALTERS, WEST, VIA MARTINEZ, TO TORO; THENCE NORTH TO INDIO.

Walters, 27 feet northwest of station, in corner of yard; iron post stamped "—189 T" (below sea level)	—188.341
Martinez Indian school, 40 feet southeast of, at northeast side of entrance to yard; iron post stamped "—135 T"	—134.114
Toro Indian Village, north side of, in northeast angle of intersection of road north to Indio with road east and west; iron post stamped "—111 T"	—110.122
Indio, 4.7 miles south of, sec. 12, T. 5. S., R. 7 E., at south side quarter corner; iron post stamped "—62 T"	— 61.125

INDIO, WESTERLY, VIA WHITEWATER RIVER ROAD, TO PALMDALE.

Indian Well, 70 feet south of; iron post stamped "97 T"	97.744
Indian Well, 3.9 miles northwest of, sec. 17, T. 5 S., R. 6 E., 6 feet south of road; iron post stamped "181 T"	181.549
Indian Well, 7.12 miles northwest of, sec 12, T. 5 S., R. 5 E., 7 feet north of road and 25 feet north of spur of mountain; iron post stamped "230 T"	230.757
Palm Springs, 4.33 miles southeast of, sec. 29, T. 4 S., R. 5 E., 12 feet south of road, at point of mountain; iron post stamped "323 T"	323.654

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[a] For additional elevations on this quadrangle refer to Farmer's double primary line, Colton to Yuma, along Southern Pacific Railway, p. 30.

VANDEVENTER, EAST ALONG TRAIL AND MARTINEZ CANYON, TO MARTINEZ.

	Feet.
Vandeventer, 4 miles northeast of, 3 feet north of north bank of sand wash, 165 feet southwest of point where trail to Martinez leaves wash, in face of white ledge 2.5 by 3 by 2.5 feet; bronze tablet stamped "3871 T"	3,871.854
Deep Canyon, 40 feet west of edge of west bluff, 15 feet north of trail, in top of granite bowlder 4.5 by 5 by 3 feet; bronze tablet stamped "3492 T"	3,492.906
Summit of divide between Deep and Martinez canyons, on west slope of Martinez Mountain, 25 feet northeast of trail, in southeast face of granite bowlder 4 by 5 by 6 feet; bronze tablet stamped "5168 T"	5,168.832
Agua Alta Spring, 235 feet southwest of, on northeast side of trail, 70 feet northwest of sand wash, on northwest side of granite bowlder 3.5 by 5 by 6 feet; bronze tablet stamped "4282 T"	4,282.623
Martinez Canyon, south side of, opposite mouth of Casa de Tahquitz Canyon, 420 feet from foot of steep side of trail, in top of flat granite bowlder 2 by 8 by 9 feet; bronze tablet stamped "2537 T"	2,537.378
Martinez Canyon, 270 feet below junction with Black Canyon, in face of granite cliff on south side of wash; bronze tablet stamped "1584 T"	1,584.808
Martinez Canyon, north side of, at mouth, 5 miles southwest of Martinez Indian school, in face of granite cliff 4 feet above ground; bronze tablet stamped "655 T"	655.841

WALTERS, SOUTH ALONG ROAD, TO SOUTH SIDE SEC. 26, T. 9 S., R. 9 E.

Alamo Bonito, south side of, near water hole, in triangle between roads; iron post stamped "—186 T"	—185.201
Agua Dulce, at north end of Indian Village, 300 feet south of spring and garden, in road forks; iron post stamped "—183 T"	—182.286
Figtree John, 140 feet southwest of reservoir at spring, 5 feet west of road, opposite fence corner; iron post stamped "—196 T"	—196.250
Fish Spring, 1.12 miles south of, 6 feet east of road; iron post stamped "—233 T"	—232.178
T. 9 S., R. 9 E., sec. 26, south side of section, 4.12 miles southeast of Fish Spring, 7 feet east of road; iron post stamped "—175 T"	—174.116

AT SEVENTEEN PALMS (SOUTH SIDE SEC. 35, T. 10 S., R. 8 E.)

Seventeen Palms, 165 feet south of chimney, on west side of road; iron post stamped "410 T"	410.828

SALTON QUADRANGLE.[a]

SEC. 26, T. 9 S., R. 9 E., SOUTH TO CLAY POINT.

T. 10 S., R. 9 E., quarter corner south side of sec. 12; iron post stamped "—39 T" (below sea level)	—38.128
Clay Point, in forks of road at junction with road to water holes; iron post stamped "36 T"	36.846

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[a] For additional elevations on this quadrangle refer to Farmer's double primary line, Colton to Yuma, along Southern Pacific Railway, p. 31.

CLARK LAKE QUADRANGLE.

CLAY POINT, SOUTHWEST ALONG TRAIL AND NORTHWEST, TO SEVENTEEN PALMS.

	Feet.
T. 11 S., R. 9 E., southeast corner of sec. 4; iron post stamped “71 T”	71.904

SEVENTEEN PALMS, SOUTHWEST ALONG TRAIL TO BOREGO SPRINGS.

Seventeen Palms, 3.2 miles southwest of, 8 feet east of road; iron post stamped “367 T”	367.889
T. 11 S., R. 7 E., northeast corner of sec. 24; iron post stamped “336 T”	336.779
Borego Springs, 60 feet south of, 25 feet north of cabin; iron post stamped “452 T”	452.906

SAN LUIS REY 30′ QUADRANGLE.

TEMECULA, ALONG ROAD SOUTH VIA RAINBOW TO SEC. 31, T. 10 S., R. 3 W. (DOUBLE-RODDED LINE.)

Temecula, in west foundation wall of schoolhouse; bronze tablet stamped “1019”	1,019.651
Temecula, 3.75 miles southeast of, east side of road, in north face of granite bowlder 18 feet high and 12 feet broad; copper bolt stamped “U. S. G. S. 1155 Ft.”	1,155.785
Rainbow post-office, 1.5 miles north of, on west side of Temecula road, in south end of bowlder 2.5 feet high, 15 feet long, and 5 feet wide, under a double oak tree in fence line; copper bolt stamped “U. S. G. S. 1164 ft. B. M.”	1,164.781
Rainbow, at northeast corner of Vallecitos schoolhouse grounds; iron post stamped “1044”	1,044.696
T. 10 S., R. 2 W., northwest corner, 200 feet south of oak tree on west side of Rainbow-Bonsall road at junction with Palla road; iron post stamped “290”	290.735
San Luis Rey River, north bank of, on north side of Bonsall-Palla road, in granite bowlder; copper bolt stamped “U. S. G. S. 274 Ft. B. M.”	274.860
Bonsall, in center of street north of post-office, in top of bowlder 12 feet in diameter, 6 feet high; copper bolt stamped “U. S. G. S. 172 Ft. B. M.”	172.821
Bonsall, 2.25 miles south of, at junction of Vista and Oceanside roads, near fence corner; iron post stamped “155”	155.873

SPUR FROM 2 MILES EAST OF SAN LUIS REY, NORTH TO SOUTHWEST CORNER SEC. 34, T. 10 S., R. 4 W.

T. 10 S., R. 4 W., southwest corner of sec. 34, 24 feet northeast of forks of road; iron post stamped “112 T”	112.714

TEMECULA, EAST UP TEMECULA RIVER, TO VICINITY OF PAUBA GRANT.

Pauba ranch house, 0.25 mile south of, northeast of forks of road; iron post stamped “1090 T”	1,090.773
Temecula, 6.5 miles east of irrigating ditch and double fork road, north of road; iron post stamped “1161 T”	1,161.702
Temecula, 8.5 miles east of, southeast corner of private road crossing, just west of dry wash of Temecula River; iron post stamped “1228 T”	1,228.775

MONSERATE SCHOOL, EAST VIA PALA, TO VICINITY OF PAUMA RANCH.

	Feet.
Monserate schoolhouse, 2 feet south of, under window; iron post stamped "351 T"	351.728
Pala, 10 feet south of southwest corner of mission; iron post stamped "411 T"	411.674
Pala, 1.75 miles east of, at fork of road to Aqua Tibia ranch, northeast of road; iron post stamped "568 T"	569.030
Pala, 3 miles east of, fork of road to Pala Mills, north of road; iron post stamped "557 T"	557.729
Pauma ranch, southeast of fork of road to ranch house; iron post stamped "758 T"	758.708

SPUR SOUTH FROM PALA 2 MILES.

Pala, 2 miles south of, northeast of forks of road; iron post stamped "481 T"	481.799

NEAR OUTING, SOUTHWEST TO DELUZ; THENCE SOUTH TO DELUZ STATION.

Sandia Canyon, in forks of Linda Rosa and Fallbrook road and road to Deluz; iron post stamped "837 T"	837.422
Deluz, 1.25 miles south of, 30 feet west of forks of road to schoolhouse (Deluz), in bed rock; copper bolt stamped "379 T"	379.909
Deluz Station, 12 feet northwest of switch south of; iron post stamped "146 T"	146.825

RAINBOW, WEST VIA FALLBROOK, TO DELUZ STATION.

Red Mountain ranch, just east of, northwest of forks of road; iron post stamped "1063 T"	1,063.660
Fallbrook, 50 feet north of schoolhouse, south side of Elder street; iron post stamped "732 T"	732.660

DELUZ STATION, SOUTH ALONG SOUTHERN CALIFORNIA RAILROAD, TO YSIDORA; THENCE WEST TO LAS FLORES.

Santa Margarita ranch house, southwest corner of retaining wall around, in middle pin; bronze tablet stamped "87 T"	87.657
Ysidora, 40 feet east of track, north side of road at fence corner; iron post stamped "23 T"	23.579
Ysidora, 1.5 miles west of, north of road at summit; iron post stamped "411 T"	411.696
Las Flores, 10 feet southwest of water tank, east of track; iron post stamped "84 T (S. B (?))" (recovered by U. S. Coast and Geodetic Survey)	84.744

LAS FLORES, NORTHEAST UP LAS PULGAS CANYON, TO LAS PULGAS CORRAL.

Las Pulgas corral, 0.5 mile northeast of, east side of Las Flores Creek, on side of hill; iron post stamped "293 T"	293.652

ESCONDIDO 15′ QUADRANGLE (SAN LUIS REY 30′ QUADRANGLE).

BONSALL, SOUTHEAST TO MOOSA.

Moosa, 15 feet southwest of house next east of post-office; iron post stamped "458 T"	458.821

NEAR BONSALL, SOUTH TO VISTA; THENCE SOUTHEAST, ALONG SOUTHERN CALIFORNIA RAILROAD AND COUNTY ROAD, TO GREEN VALLEY (DOUBLE-RODDED LINE).

	Feet.
Delphi, northwest corner of schoolhouse grounds; iron post stamped "491"	491.806
Vista, 50 feet northeast of Escondido Branch Railroad track, on southwest side of county road, in row of eucalyptus trees east of railroad crossing; iron post stamped "330"	330.870
San Marcos, close to schoolhouse building, in angle of porch and building in front; iron post stamped "582"	582.826
Richland, in row of eucalyptus trees at southern corner of school grounds, 50 feet northeast of track and 35 feet northwest of road center; iron post stamped "634."	634.920
Escondido, northeast corner of iron footplate of step at entrance to drug store, on lot 15, next to bank and post-office building, on Main street; official city bench mark	654.661
Escondido, in north wall of main entrance to corridor in basement of college building on hill, 4 feet above ground; bronze tablet stamped "754"	754.948
Escondido, 2.5 miles south of, on San Diego road at junction; iron post stamped "530"	530.959
Bernardo post-office, 625 feet north of Bernardo River bridge, on west side of county road; iron post stamped "319"	319.983
Green Valley, in sloping bowlder 4 feet high, east of large bowlder pile, west side of San Diego road and 80 feet north of bridge; copper bolt stamped "U. S. G. S. 482 ft. B.M."	482.976

BERNARDO, NORTHEAST ALONG RIVER ROAD, TO SAN PASQUAL.

Glenella schoolhouse, 80 feet southwest of, in yard; iron post stamped "381 T"	381.763
San Pasqual schoolhouse, in yard at east side of gate; iron post stamped "366 T"	366.791

OCEANSIDE 15′ QUADRANGLE (SAN LUIS REY 30′ QUADRANGLE).

YSIDORA, SOUTHEAST TO SAN LUIS REY; THENCE NORTHEAST TO NEAR BONSALL.

San Luis Rey, northeast corner of grounds around schoolhouse; iron post stamped "76 T"	76.579

RAMONA QUADRANGLE.

AT WILSON VALLEY.

T. 8 S., R. 1 E., about southwest corner sec. 2 in Wilson Valley, 4 feet east of lowest point of road; iron post stamped "2146"	2,146.866

PAUBA GRANT, SOUTHEAST VIA OAK GROVE, TO WARNER RANCH.

Nigger Canyon, 1.75 miles southeast of, 10 feet south of road, at junction of Temecula-Warner road with road to north, 120 feet southwest of box elder tree; iron post stamped "1450 T"	1,450.683
Radec post-office, 0.25 mile north of, at junction with road to San Jacinto; iron post stamped "1694 T"	1,694.668
Cienega schoolhouse, 2 feet south of fence and 3 feet east of front gate; iron post stamped "1988 T"	1,988.615

	Feet.
Cienega schoolhouse, 2.75 miles southeast of, in flat draw, 10 feet north of road; iron post stamped "2439 T"	2, 439. 679
Oak Grove schoolhouse, 50 feet south of, in yard, at east side of gate; iron post stamped "2751 T"	2, 751. 637
Oak Grove schoolhouse, 4 miles southeast of, sec. 35, T. 9 S., R. 2 E., about 400 feet west of quarter corner, 10 feet west of road on summit of divide between Temecula and San Luis Rey rivers, 3 feet east of fence corner; iron post stamped "3282 T"	3, 282. 746
Puerta Cruz, 0.5 mile northeast of, 25 feet south of road; iron post stamped "2916 T"	2, 916. 746
Warner's ranch, 0.5 mile northeast of Adobe Cabin corral, north side of Agua Caliente Creek bed, in southeast corner of intersection of road from ranch house to corral with Temecula-Julian road; iron post stamped "2772 T"	2, 772. 733

WARNER'S RANCH, WEST VIA SAN LUIS REY CANYON AND POTRERO INDIAN RESERVATION, TO PAUMA GRANT.

San Luis Rey Canyon, head of, 45 feet west of road above foot of grade in first bend of Smith Mountain; iron post stamped "2724 T"	2, 724. 628
Amago post-office, 3.33 miles southeast of, at east side of trail in San Luis Rey Canyon, south side of creek, 100 feet west of junction of dry creek bed from south with San Luis Rey River, on west side of granite ledge; bronze tablet stamped "2404 T"	2, 404. 694
Lajolla, at southwest corner of, Indian reservation schoolhouse; iron post stamped "2719 T"	2, 719. 777
Sparkman's store, 45 feet northwest of, 2 feet northeast of stone fence on southwest side of road; iron post stamped "1016 T"	1, 016. 622

SPARKMAN'S STORE, SOUTH VIA RINCON, TO T. 11 S., R. 1 W.

Rincon schoolhouse, 1.87 miles south of, 0.5 mile south of San Luis Rey River crossing, at junction of road to Escondido with road up creek; iron post stamped "939 T"	939. 583

ADOBE CABIN CORRAL ON WARNER'S RANCH, EAST TO AGUA CALIENTE; THENCE SOUTHEAST TO POINT 1 MILE EAST OF WARNER SCHOOLHOUSE; THENCE NORTHWEST TO ADOBE CABIN CORRAL.

Agua Caliente schoolhouse, southwest corner of; iron post stamped "3165 T"	3, 165. 634
Warner schoolhouse, 3.25 miles north of, T. 10 S., R. 3 E., 150 feet east of road and 5 feet east of southwest corner of building; iron post stamped "3459 T"	3, 459. 682
Warner schoolhouse, 1 mile east of, 50 feet east of junction of old Fort Yuma road with road to east; iron post stamped "3240 T"	3, 240. 601
Warner ranch house, in forks of road at southwest corner of; iron post stamped "2894 T"	2, 894. 681

HEAD OF SAN LUIS REY CANYON, SOUTHEAST TO SANTA YSABEL; THENCE WEST, VIA RAMONA, TO SAN PASQUAL.

Mesa Grande road, 400 feet southwest of end of lane; iron post stamped "2719 T"	2, 719. 614

	Feet.
T. 11 S., R. 3 E., north side of sec. 32, Santa Ysabel ranch boundary line, 5 feet south of intersection with section line; iron post stamped "3015 T"	3, 015. 636
Balcon Canyon, in forks of road; iron post stamped "3123 T"	3, 123. 792
Santa Ysabel, 180 feet west of road junction and south side of road; iron post stamped "2983 T"	2, 983. 684
Santa Ysabel schoolhouse, in yard at north side of gate; iron post stamped "2764 T"	2, 764. 738
Ballena schoolhouse, 60 feet south of, in yard at east side of gate; iron post stamped "2470 T"	2, 470. 640
Mesa Grande, in forks of road; iron post stamped "1776 T"	1, 776. 729
Ramona town hall, east side of, 0.5 foot above step; aluminum tablet stamped "1440 T"	1, 440. 697
Pamo grade, 0.2 mile south of forks of road, west of road, in turntable; iron post stamped "789 T"	789. 624
East San Pasqual, 1 mile east of, 95 feet north of schoolhouse, in yard, 3 feet from fence at west side of gate; iron post stamped "410 T"	410. 636

JUNCTION OF ROAD 3 MILES EAST OF RAMONA, NORTH TO SPRING HILL SCHOOLHOUSE.

T. 12 S., R. 2 E., sec. 32, Spring Hill schoolhouse, 55 feet west of, in yard at south side of gate; iron post stamped "2340 T"	2, 340. 666

SAN YSABEL, EAST TO JULIAN; THENCE NORTH TO OBERLIN SCHOOLHOUSE.[a]

Wynola, at northeast corner of road intersection; iron post stamped "3654 T"	3, 654. 600
Julian, 1.75 miles west of, at southwest corner of junction of main road with private road to south; iron post stamped "3948 T"	3, 948. 690
Julian high schoolhouse, in yard at north side of gate; iron post stamped "4219 T"	4, 219. 765
Oberlin schoolhouse, in yard at north side of gate; iron post stamped "4132 T"	4, 132. 471

CUCAMONGA, DEEP CREEK, HESPERIA, POMONA, ROCK CREEK, SAN ANTONIO, SAN BERNARDINO AND VICTOR 15′ QUADRANGLES; SAN GORGONIO 30′ QUADRANGLE.

LOS ANGELES AND SAN BERNARDINO COUNTIES.

The elevations in the following list are based upon the 1906 precise-level line of the United States Coast and Geodetic Survey from San Diego which recovered several bench marks of this list on San Bernardino, Hesperia, and Victor quadrangles.

The leveling of Pomona, Cucamonga, and on part of San Bernardino quadrangles was done in 1897 by Mr. H. S. Crowe, levelman; other leveling was done on San Bernardino, Hesperia, and Victor quadrangles in 1898; on Hesperia, Victor, and Deep Creek quadrangles in 1898–99, and on San Antonio and Rock Creek quadrangles in 1899, under Mr. W. T. Turner, topographer, by Mr. C. R. Smith, levelman. The leveling on San Gorgonio quadrangle was done in 1899 under Mr. E. T. Perkins, topographer, by Messrs. C. R. Smith, R. A. Hamilton, and C. C. Ward, levelmen.

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[a] A line from south closes 1.6 feet high on Julian.

POMONA QUADRANGLE.

BASSETT, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO POMONA (DOUBLE-RODDED LINE).

	Feet.
Bassett, 86.7 feet from west end of platform and 107.7 feet south of southwest corner of station; iron post stamped "295"	295.540
Puente, 18 feet west of turnstile in fence north of station, 125 feet north of east end of platform; iron post stamped "328"	328.659
Puente warehouse, 1.4 feet from northwest corner and 1.2 feet below brick foundation; bronze tablet stamped "331"	331.745
Lemon, in southeast corner of fence of railroad reservation and 113.2 feet from southwest corner of station; iron post stamped "519"	519.879
Spadra, 122.4 feet from northwest corner of station; iron post stamped "711"	711.998
Pomona, 55 feet from station, near telegraph pole near park hedge; iron post stamped "861"	861.738
Pomona, in Odd Fellows Building, corner Second and Ellen streets, on Ellen street side, 11.6 feet from Second street corner, in third course from window and 8.5 courses from sidewalk; bronze tablet stamped "854"	855.069

CUCAMONGA QUADRANGLE.

POMONA, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO SOUTH ETIWANDA (DOUBLE-RODDED LINE).

Pomona, J. H. Graber building, corner railroad reservation and Gordon street, northwest corner of Gordon street, four rows from corner, 7 courses from sidewalk; bronze tablet stamped "861"	861.992
Ontario, in grass plot in front of station, 79.2 feet south of southwest corner of station; iron post stamped "986"	986.375
Ontario, in southwest corner of Southern Pacific Hotel, seventh course from sidewalk and two courses from doorway on west side of building; bronze tablet stamped "992"	992.315
Ontario, in northwest corner of bank building, on Main avenue, second corner from steps, eighth course above sidewalk; bronze tablet stamped "987"	987.830
South Cucamonga (Zucker), in station park, 45.1 feet from southeast corner of station and 2.6 feet from telegraph pole; iron post stamped "958"	958.556
South Etiwanda, 58.6 feet south of center of wagon road and 2.6 feet west of telegraph pole; iron post stamped "981"	982.134

SAN BERNARDINO QUADRANGLE.

RIVERSIDE, NORTHEAST TO HIGH GROVE.

High Grove, station park south end of diamond-shaped lawn; iron post stamped "945" (recovered by U. S. Coast and Geodetic Survey)	945.517

RIVERSIDE, NORTHEAST ALONG MOTOR RAILROAD, TO SAN BERNARDINO; THENCE NORTHWEST ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO KEENBROOK.

	Feet.
Colton, 1 mile northeast of, at Lytle Creek, in northeast cylinder on east side of wagon-road bridge; copper bolt stamped "1007"	1,007.486
San Bernardino, in stone on northeast corner of court-house building; bronze tablet stamped "1048" (recovered by U. S. Coast and Geodetic Survey)	1,048.451
Verdemont, 2.8 miles southward from, 50 feet east of track at point where 3 wagon roads pass over one common crossing; iron post stamped "1420 S B" (recovered by U. S. Coast and Geodetic Survey)	1,420.770
Glen Helen ranch, on east side of county road; iron post stamped "2008 S B" (recovered by U. S. Coast and Geodetic Survey)	2,009.267

SOUTH ETIWANDA, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO MOUND CITY (DOUBLE-RODDED LINE).

San Sevaine, on south side of track, 231 feet from southwest corner of station, near fence; iron post stamped "1063"	1,063.238
Bloomington, south side of track, 87.9 feet from southeast corner of station, 2.2 feet from telegraph pole and 7 feet from center of wagon road; iron post stamped "1090"	1,090.279
Bloomington, in brick building at post-office, in sixth course of brick above foundation and second course from southeast corner of building owned and occupied by W. H. H. Easton, southwest corner of Orchard and Commercial streets; bronze tablet stamped "1098"	1,099.141
Colton, 1.25 miles west of, at Cement Company's storehouse, in wall on north side, 3.4 feet from east corner, 0.7 foot from top of foundation, 35.8 feet from center of track; bronze tablet stamped "1006"	1,006.665
Colton, in corner of brick building at Transcontinental Hotel, in third course above top of corner post and in center of brick laid horizontally; bronze tablet stamped "978"	979.073

COLTON, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO VICINITY OF PALM SPRINGS.

Mound City, northeast corner of reservoir wall east of station; copper bolt stamped "1079"	1,079.762

ROCK CREEK QUADRANGLE.[a]

NORTH SIDE SEC. 4, T. 4 N., R. 8 W., WEST TO ROCK CREEK; THENCE SOUTHEAST TO SHOEMAKER (BIG ROCK VILLA).

Sheep Creek, 14.5 miles west of, at forks where second road to Palmdale branches to northwest; iron post stamped "3497 S B"	3,497.687
Shoemaker's ranch, on Rock Creek, 50 feet west of hotel; iron post stamped "3927 S B"	3,927.355

SAN ANTONIO QUADRANGLE.

APPLEWHITE, NORTHWEST VIA NORTH FORK OF LYTLE CREEK AND LONE PINE CANYON ROADS, TO CENTER OF T. 3 N., R. 7 W.; THENCE NORTH AND EAST ALONG SHEEP CREEK ROAD, TO TAMBORINO (10 MILES WEST OF HESPERIA).

Glen (Applewhite) ranch, 5.45 miles northwest of, at mouth of Coldwater Canyon, near first pine tree above forks of road; iron post stamped "5017 S B"	5,017.766

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[a] These elevations are possibly in error on account of closure on line from southeast about 3 feet high.

	Feet.
Hesperia, 24.65 miles southwest of, at forks where Swartout road branches off to the west, north side of road; iron post stamped "6006 S B"	6,006.428
Hesperia, 19.35 miles southwest of, at forks where main traveled road branches off to northwest to Palmdale and Lancaster, west side of road; iron post stamped "4429 S B"	4,429.322
Hesperia, 10 miles west of, south side of road at the Tamborino ranch; iron post stamped "3740 S B"	3,740.127

MOUTH OF SHEEP CREEK, NORTHWEST ALONG LANCASTER AND PALMDALE ROAD, TO SEC. 4, T. 4 N., R. 8 W.

Sheep Creek, 8 miles west of, in front of deserted frame dwelling house on south side of road; iron post stamped "3763 S B" (possibly 3 feet too high)	3,763.393

SHEEP CREEK SUMMIT, WEST UP SWARTOUT VALLEY, TO SHOEMAKER.

Swartout road summit, on south side of road in gap; iron post stamped "6862 S B" (true elevation is possibly 3 feet higher)	6,862.311

HESPERIA QUADRANGLE.

KEENBROOK, NORTHEAST ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO VICTOR.

Cosy Dell road station, inside of garden fence east of county road; iron post stamped "2768 S B"	2,768.147
Cajon, 4.75 miles north of, at point where county road recrosses railroad track, west side of track; iron post stamped "3685 S B"	3,684.985
Summit station, 5.2 miles north of, where second wagon road crosses railroad, 40 feet west of track and 20 feet north of wagon road; iron post stamped "3462 S B" (recovered by U. S. Coast and Geodetic Survey)	3,462.665
Hesperia, at northeast corner of red brick hotel building; iron post stamped "3190 S B" (recovered by U. S. Coast and Geodetic Survey)	3,190.475
Hesperia, 4.75 miles north of, cross on north end of coping of small cement culvert west side of track (recovered by U. S. Coast and Geodetic Survey)	2,856.822

HESPERIA, WEST ALONG ROAD, TO TAMBORINO RANCH; THENCE NORTHEAST, ALONG NORTH BRANCH OF SHEEP CREEK, TO POINT 5 MILES WEST OF VICTOR.

Hesperia, 5 miles west of, at junction of road to Tamborino ranch with road from Oro Grande to San Bernardino, via Cajon Pass; iron post stamped "3522 S B"	3,522.120
Hesperia, 10 miles west of, at southeast corner of Tamborino ranch, on south side of Sheep Creek road, 30 feet southeast of corner common to secs. 13, 14, 23, and 24, T. 4 N., R. 6 W.; iron post stamped "3740 S B"	3,740.127

KEENBROOK, NORTHWEST TO APPLEWHITE (GLEN) RANCH.

Applewhite (Glen) ranch, 40 feet west of westernmost building; iron post stamped "3256 S B"	3,256.940

SUMMIT, EAST TO BURCHAM'S RANCH; THENCE SOUTHWEST ALONG CLEGHORN CANYON, TO COSY DELL.

	Feet.
Burcham's ranch, on east end of south side rail of large cattle scales; cross cut on iron plate	3,181.54
Ts. 2 and 3 N., Rs. 4 and 5 W., 400 feet south of common corner, on left side of road by gate in west fence of Wixum's ranch on West Fork of Mohave River; iron post stamped "3355 S B"	3,354.966

VICTOR QUADRANGLE.

VICTOR, WEST ALONG ROAD 5.2 MILES.

Victor, 60 feet north of wagon bridge over Mohave River and 60 feet west of track; iron post stamped "2723 S B" (recovered by U. S. Coast and Geodetic Survey)	2,723.202
Victor, south end of veranda of Turner Hotel; cross chiseled on west end of top stone step	2,716.77
Victor, 5.25 miles west of, at point where Oro Grande and San Bernardino road crosses road from Victor to Sheep Creek; iron post stamped "3063 S B"	3,063.594

DEEP CREEK QUADRANGLE.

VICTOR, SOUTHEAST ALONG OLD TELEGRAPH ROAD, TO FIFTEENMILE POINT.

Victor, 5.75 miles southeast of, on Rocksprings and Old Telephone Line roads, 6 feet right of latter road, on brow of second bench land; iron post stamped "2960 S B"	2,959.960
Fifteenmile Point, 0.5 mile east of where road from Victor joins old stage road from San Bernardino to Rabbit Springs; iron post stamped "3010 S B"	3,010.780

HESPERIA, EAST VIA BEAR VALLEY AND RABBIT SPRINGS ROAD, TO FIFTEENMILE POINT.

Mohave River, on brow of first bench land east of, 4 feet north of Bear Valley road; iron post stamped "3097 S B"	3,097.041

JUNCTION OF RABBIT SPRINGS AND BEAR VALLEY ROADS, SOUTHEAST ALONG BEAR VALLEY ROAD TO COXEY'S RANCH; THENCE WEST DOWN DEEP CREEK, TO MOHAVE RIVER.

Rock Springs, in triangle of roads; iron post stamped "3748 SB"	3,748.181
Coxey's ranch, in corner of garden fence; iron post stamped "5619 S B"	5,619.653
Deep Creek, Hesperia Land and Water Company's diversion dam; surface of top of cement work	3,366.54

HESPERIA, SOUTHEAST ALONG PIPE LINE, TO MOHAVE RIVER (SOUTHWEST CORNER, SEC. 7, T. 3 N., R. 3 W.); THENCE SOUTHWEST TO BURCHAM'S RANCH.

T. 3 N., R. 3 W., southwest corner sec. 7, 7 miles southeast of Hesperia; iron post stamped "2960 S B"	2,960.131

COXEY'S RANCH, SOUTHEAST 4.3 MILES, TO JUNCTION OF ROAD TO PINE FLATS.

Coxey's ranch, 4.3 miles southeast of, at point where road to Pine Flat branches off, in forks of road; iron post stamped "6823 SB"	6,823.543

SAN GORGONIO 30′ QUADRANGLE.

FIFTEENMILE POINT, EAST TO BOX S RANCH (1 MILE SOUTHEAST OF RABBIT SPRINGS); THENCE SOUTHEAST TO NEAR CACTUS SPRINGS; THENCE WEST, VIA HOLCOMB VALLEY, TO POINT 4.3 MILES EAST OF COXEY'S RANCH.

	Feet.
Box S ranch, sec. 11, T. 4 N., R. 1 W., south side of section, in front of dwelling house; iron post stamped "2935 S B"	2,936.196
Box S Springs, sec. 4, T. 3 N., R. 1 E., northeast corner of section, 6.25 miles southeast of Box S ranch, at east end of watering trough; iron post stamped "3550 S B"	3,550.149
Cactus Flat, at northeast corner of picket fence in front of James Johnson's residence; + on embedded square stone monument	5,878.91
Cactus Flat, 1 mile southeast of, sec. 30, T. 3 N., R. 2 E., where road branches off to the south from road to Rose Mine; iron post stamped "6031 S B"	6,031.796
Holcomb Valley, sec. 31, T. 3 N., R. 1 E., in front of offices of Holcomb Valley Mining Company; iron post stamped "7239 SB"	7,240.028

HOLCOMB VALLEY, SOUTH 3 MILES, TO BEAR LAKE; THENCE WEST TO FAWNSKIN VALLEY; THENCE NORTHEAST TO HOLCOMB VALLEY.

Holcomb Valley, 3.5 miles southeast of, where west branch of Poligue Canyon road joins Bear Valley road to San Bernardino; iron post stamped "6761 S B"	6,761.879
Fawnskin Valley, upper end of, where Holcomb Valley road forks to the northeast; iron post stamped "7211 S B"	7,211.964

BAIRDSTOWN (SOUTH OF CACTUS FLAT), SOUTHEAST VIA ROSE MINE, TO MOUND SPRINGS; THENCE NORTH TO OLD WOMANS SPRINGS; THENCE SOUTHWEST TO CUSHENBERRY.

Baldwin Lake, 0.75 mile east of, at junction of road from Rose mine to Bear Valley with road to Bairdstown, in road forks; iron post stamped "6773 S B"	6,773.415
Rose mine, at southeast corner of cook house; iron post stamped "6867 S B"	6,867.597
Old Womans Springs, 3.5 miles south of, west side of road, 400 feet north of where it leaves Rattlesnake Canyon and runs north toward springs; iron post stamped "3659 S B"	3,659.745
Old Womans Springs, 40 feet south of house, 4 feet from cottonwood tree 1 foot in diameter; iron post stamped "3186 SB"	3,186.544
Old Womans Springs, 4.5 miles west of, on north of road, opposite junction of road with road to southeast, where road goes between two small hills; iron post stamped "3565 S B"	3,565.512

WHITEWATER STATION, NORTH VIA CHUCK WARREN'S, TO "THE PIPES;" THENCE NORTHWEST TO ROSE MINE.

Dry Morongo, about sec. 9, T. 2 S., R. 4 E., on west side of canyon at junction with Mission Creek Valley, 15 feet west of road junction; iron post stamped "1800 S B"	1,800.475
Warren's ranch, sec. 28, T. 1 S., R. 4 E., at gatepost, 110 feet south of barn; iron post stamped "2504 S B"	2,504.499
T. 1 S., R. 4 E., sec. 14, 100 feet southwest of northeast corner, in forks of Little Morongo Canyon road, where it branches from road to Virginia Dale; iron post stamped "2745 S B"	2,745.674

	Feet.
Little Morongo Canyon, sec. 2, T. 1 S., R. 4 E., mouth of lateral canyon, at junction with trail to The Pipes, at upper end of timber patch, 3 feet above ground, in face of granite cliff; aluminum tablet stamped "3380 S B"	3,380.536
The Pipes, 20 feet northeast of house, 45 feet southwest of barn, 2 feet east of yucca tree; iron post stamped "4459 S B"	4,459.430
Burns Spring, 1.75 miles northwest of, in saddle of small spur ridge, at top of first steep hill out of canyon; iron post stamped "5438 S B"	5,438.270
Rattlesnake Canyon, 1.1 miles southeast of, at junction of road from The Pipes to Rose Mine with road to Old Womans Springs, 23 feet west of piñon tree; iron post stamped "5736 S B"	5,736.444

WHITEWATER SIDING, NORTHWEST ALONG WHITEWATER CANYON, TO SEC. 36, T. 1 S., R. 2 E.

Whitewater Creek, sec. 36, T. 1 S., R. 2 E., 475 feet southwest of junction with creek from the south, southwest side of Whitewater Canyon, 500 feet south of cluster of pine trees, in vertical face of granite ledge, 1.5 feet above ground; aluminum tablet stamped "3438 S B"	3,438.608

DRY MORONGO, WEST TO CORNER OF TS. 1 AND 2 S., RS. 3 AND 4 E.

Ts. 1 and 2 S., Rs. 3 and 4 E., common corner, which is also corner of the San Bernardino Forest Reserve and is marked "No. 99" in top of cement-filled iron post 4 inches square; aluminum tablet stamped "3075 S B"	3,075.519

SEC. 14, T. 1 S., R. 4 E., NORTHWEST UP LITTLE MORONGO CANYON, TO T. 1 N., RANGE 4 E. (ABOUT SEC. 30, UNSURVEYED).

Little Morongo, on south side of canyon, at second water camping place, in red granite ledge 10 feet above creek bed; aluminum tablet stamped "4831 S B"	4,831.526

CALABASAS, DOWNEY, FERNANDO, GOLETA SPECIAL, HUENEME, PASADENA, REDONDO, SAN PEDRO, SANTA BARBARA SPECIAL, SANTA MONICA, SANTA PAULA, SANTA SUSANA, TUJUNGA, AND VENTURA 15′ QUADRANGLES; CAMULOS, GUADALUPE, LOMPOC, MOUNT PINOS, PALMDALE, SANTA YNEZ, AND TEJON 30′ QUADRANGLES.

KERN, LOS ANGELES, SAN LUIS OBISPO, SANTA BARBARA, AND VENTURA COUNTIES.

The elevations in the following list are based upon the 1906 precise-level line of the United States Coast and Geodetic Survey from San Diego along the Atchison, Topeka and Santa Fe Railroad via San Bernardino to Barstow, and are derived by a readjustment of leveling mostly heretofore published in Bulletin No. 185 and in Appendix to the Nineteenth Annual Report. The elevations previously published were based upon double-rodded primary lines from Los Angeles to Pacoima, Santa Monica, San Bernardino, and San Pedro, based upon the United States Coast and Geodetic Survey gage record at San Pedro. The unadjusted values corrected to San Bernardino would now close 0.7 foot high at San Pedro and 0.2 foot low at Santa Monica, but an adjustment has been made arbitrarily adding 0.4

foot at San Pedro and 0.9 foot to the elevation (see Nineteenth Annual Report) at Santa Monica to equal the Coast and Geodetic Survey value there; also 0.5 foot has been added at Los Angeles and 0.7 foot at Pacoima. The elevations are further controlled by precise leveling of 1902 along the Southern Pacific Railway from Pacoima to Mohave, bearing additional rod correction found by rerunning a portion in 1906 near Mohave, and adjusted to the new accepted heights at these points.

The leveling was done as follows: By Mr. H. S. Crowe, levelman, on San Pedro, Redondo, Downey, Pasadena, and Tujunga quadrangles in 1897; on Fernando quadrangle in 1897–98; on Santa Monica quadrangle in 1897 and 1900; on Santa Susana quadrangle in 1898 and 1900; on Calabasas 15′ and remainder of Camulos 30′ quadrangles in 1900; on Hueneme and Santa Paula quadrangles in 1900 and 1901; on Ventura, Santa Barbara Special, and Mount Pinos quadrangles in 1901; on Palmdale quadrangle in 1900; on Tejon quadrangle in 1900 and 1901; and on Goleta Special, Santa Ynez, and Lompoc quadrangles in 1901–2. Additional work was done on Lompoc quadrangle in 1903–4 by Mr. S. N. Stoner, and in 1903 by Mr. C. L. Nelson. Work on Guadalupe quadrangle was done in 1903–4 by Mr. Stoner.

In the spring of 1907 a prism level yard rod line of levels was run by Mr. Charles H. Lee, for the Los Angeles aqueduct, under Mr. J. B. Lippincott, which agrees well between Pacoima, Saugus, and Mohave with the adjusted elevations of this list, but disagrees grossly with Crowe's levels of this list on Tejon quadrangle, increasing elevation at San Francisco Canyon 2 feet, lowering elevation at Fairmont 1.5 feet, and making various other corrections between these extremes, which show Crowe's lines to be somewhat unreliable; but no readjustment has been yet made of Crowe's lines on account of this information.

SAN PEDRO QUADRANGLE.

AT SAN PEDRO.

	Feet.
San Pedro, top of upper stone of foundation to brick building of Bank of San Pedro, U. S. C. & G. S. bench mark (of 1890)[a] ------	22.74

REDONDO QUADRANGLE.

SAN PEDRO, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO WILMINGTON (DOUBLE RODDED LINE).

Wilmington, 152 feet from northeast corner of railroad water tank and 153 feet from southwest corner of station; iron post stamped "7" --	6.915

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[a] To U. S. C. & G. S. elevation 0.4 foot has been added.

DOWNEY QUADRANGLE.

WILMINGTON, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO CLEMENT JUNCTION, LOS ANGELES (DOUBLE-RODDED LINE).

	Feet.
Thenard Junction, about 100 feet west of station sign and 1 foot from telegraph pole; iron post stamped "33"	33.007
Cerritos, corner of Dominquez and Railroad avenues, 1 foot from corner of fence of railroad right of way and 96 feet from southwest corner of railroad building; iron post stamped "32"	31.903
Compton, 1 foot from fence in front of station, 88 feet from northeast corner of station building and 30 feet from north post of gate to R. Barker's residence, fronting station; iron post stamped "67"	67.038
Florence, between station building and small outhouse, 39 feet from southwest corner of station building and 5 feet from large palm tree; iron post stamped "136"	136.052

PASADENA QUADRANGLE.

CLEMENT JUNCTION, NORTH VIA LOS ANGELES, TO TROPICO (DOUBLE-RODDED LINE).

Los Angeles:	
Clement Junction, at intersection of fence lines; iron post stamped "220"	220.470
Arcade station, 3 inches north of center post of northwest tower of; copper plug set in asphaltum, stamped "256"	256.179
Post-Office Building, in north stone buttress of main entrance to, on Main street, between Winston and Fifth streets; bronze tablet stamped "270"	270.619
City Hall Building, on Broadway, about 3 feet above the northern steps to front entrance; bronze tablet stamped "286"	286.633
County court-house, in granite buttress of, right hand of main steps to building, which is at southeast corner of Broadway and Temple street; bronze tablet stamped "338"	338.523
Naud Junction, in concrete of floor of waiting room, alley at, 4 inches from side of baggage room and 8 inches from edge of concrete nearest railroad track; copper bolt stamped "282"	282.733
Naud Junction, 0.5 mile east of, at Los Angeles River, southwest corner of railroad bridge, in concrete pier; copper bolt stamped "294"	294.590
Junction warehouse, brick building, at Junction of San Fernando and Olympia streets, in front wall; bronze tablet stamped "306"	306.403
Buena Vista street, bridge over Los Angeles River, 0.5 mile north of station, second bent from south end, 18 feet from California Southern and 12 feet from Southern Pacific railroad tracks, in northeast granite post; copper bolt stamped "314"	314.546

LOS ANGELES, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO BASSETT.

East Lake Inn, northeast corner of Eastlake avenue and Mission road, on south side of building and 1.2 feet from steps in concrete, at top of foundation; bronze tablet stamped "333"	333.391
Aurant station, 0.75 mile west of, in top step of brick culvert on west side of railroad; copper bolt stamped "399"	399.226
Shorb station, on south side of railroad yard, 99.5 feet southeast from corner of station and 55 feet west of signal tower building; iron post stamped "464"	464.325

	Feet.
Alhambra station, in the west corner of railroad park; iron post stamped "456"	456.547
San Gabriel, 85.6 feet from northeast corner of, and 94.9 feet from northwest corner of station building, 7.1 feet west from rain-gage post; iron post stamped "415"	415.993
Savannah, 1 foot from fence south of station and 75.9 feet from southeast corner of station; iron post stamped "300"	300.660
Savannah, in Western Union Telegraph pole, 73.3 feet north of station; bronze tablet stamped "292"	292.416

SANTA MONICA QUADRANGLE.

CLEMENT JUNCTION, LOS ANGELES, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO SANTA MONICA (ADJUSTED DOUBLE-RODDED LINE).

University station, 1 foot west of telegraph pole and 65 feet south of southwest corner of station; iron post stamped "174"	174.851
Cienega siding, at northwest corner of fence for cattle corral and 50 feet west of center of track; iron post stamped "118"	118.934
Ivy station, in southwest corner of fence of cattle guard at road crossing, 150 feet northwest of station building; iron post stamped "103"	103.180
Palms, in front brick wall at northwest corner of warehouse, fifth course of bricks above water table and in center of second course of bricks from north end; bronze tablet stamped "126"	126.909
Home Junction, on east side of track near fence, 80 feet east from center of railroad building and 48 feet from center of track; iron post stamped "165"	165.323
Santa Monica, in brick wall of building used as bank on northeast corner of Oregon and Third streets; bronze tablet stamped "79"	79.400
Santa Monica, in concrete floor of railroad turntable foundation, 3.2 feet north of center of turntable, and 6 inches west of center of track at end of Long Wharf; copper bolt stamped "17"	17.510
Santa Monica, top surface of the railroad turntable at inner end of wharf (the turntable has a well-laid concrete foundation); U. S. C. & G. S. benchmark No. 1 (elevation by U. S. C. & G. S.)	17.42

TROPICO, NORTHWEST ALONG SOUTHERN PACIFIC RAILROAD, TO PACOIMA (DOUBLE-RODDED LINE).

Tropico, 1.5 feet from northwest corner of fence around garden, 200 feet north of station building; iron post stamped "432"	432.289
Burbank, on west side of railroad track, 51 feet from center, 117 feet northwest from northwest corner of station; iron post stamped "563"	563.348
Dundee, near post-office building, 12.2 feet from northeast corner of building, 4.2 feet from eucalyptus tree, 600 feet west of railroad station; iron post stamped "760"	760.108

BURBANK, WEST ALONG CHATSWORTH PARK BRANCH RAILROAD, TO ENCINO.

MacNeil siding; top of rail	597.2
Garnsey siding; top of rail	663.6
Garnsey siding, 300 feet west of, 3.5 feet east of telegraph pole 479, 50 feet south of railroad track; iron post stamped "665 L. A."	665.635
Trestle 483 C, opposite, 50 feet south of center of track, 4 feet east of telegraph pole 484; iron post stamped "704 L. A."	704.933

FERNANDO QUADRANGLE.

PACOIMA, NORTHWEST ALONG SOUTHERN PACIFIC RAILROAD, TO FERNANDO; THENCE EAST UP TUJUNGA VALLEY INTO CANYON.

	Feet.
Pacoima, at corner of fence, 165 feet northwest of northwest corner of brick station building; iron post stamped "1013" (beginning of precise line)	1,013.230
San Fernando, in southeast corner of brick wall of McClay & McClay Company's building on Johnson street; bronze tablet stamped "1066," recovered by precise levels	1,066.665
T. 2 N., R. 14 W., sec. 10, 0.3 mile west of road fork, 40 feet south from corner of old orchard, 4 feet north of crooked tree and 20 feet from center of wagon road; iron post stamped "1187"	1,187.837
T. 2 N., R. 13 W., sec. 6, 0.75 mile east of S. A. Johnson's house, 10 feet south of wagon road on township line; iron post stamped "1470"	1,470.898

SAUGUS, EAST ALONG SOUTHERN PACIFIC RAILROAD AND HIGHWAYS, TO RAVENNA (RECOVERED BY PRECISE LEVELING).

T. 4 N., R. 15 W., 4.6 feet from common corner secs. 13, 14, 23, and 24, road over tunnel, 15 feet from fence; iron post stamped "1565"	1,564.636
Lang's station, at north end of picket fence, 45 feet north of center of track, between hotel building and section house; iron post stamped "1690" (recovered by precise levels)	1,689.544
Steel bridge No. 11, on concrete bulkhead pier of, in Soledad Canyon, 11 miles south of Acton; copper bolt stamped "1822"	1,821.790
Steel bridge No. 5, on concrete pier bulkhead at northwest corner of; copper bolt stamped "1913"	1,913.053

SPUR NORTH UP AGUA DULCE CANYON.

T. 5 N., R. 14 W., sec. 34, 1.25 miles west of J. M. Talbot's house, 2 feet south of southeast corner of adobe house; iron post stamped "2258"	2,257.840

SPUR NORTH UP MINT CANYON.

T. 4 N., R. 15 W., sec. 15, 2 miles north of railroad, in flat rock 12 by 12 by 8 inches on side of hill, about 30 feet north of spring; copper bolt stamped "1556"	1,555.511
T. 4 N., R. 15 W., sec. 2, northwest corner of W. H. Thomas's cabin, 4.75 miles from mouth of canyon; iron post stamped "1778"	1,777.721

TUJUNGA QUADRANGLE.

UP TUJUNGA CANYON, EAST ALONG ROAD, TO HOYT RANCH; THENCE NORTHEAST ALONG TRAIL UP CANYON AND OVER RIDGE, TO NORTH FORK TUJUNGA CREEK AT MOUTH OF MILL CREEK; THENCE NORTHEAST 2 MILES UP MILL CREEK, TO END OF WAGON ROAD.

Hoyt ranch, 0.7 mile northwest of, about 800 feet from creek crossing on brushy flat, 6.5 miles northeast of Montevista, in face of rock 14 by 5 by 3 feet, 2.7 feet above surface of ground; bronze tablet stamped "1888"	1,888.645

	Feet.
Hoyt's ranch, 2.75 miles northeast of, in rock at foot of slope, pine tree growing in rock; copper bolt stamped "2115"	2,115.315
Bowlder 7 by 5 by 3 feet, on trail where it is in sight of Big Tujunga, about 1,500 feet up ridge; copper bolt stamped "2593"	2,593.905
Small summit, 1.1 miles on trail, in flat granite slab; copper bolt stamped "3526"	3,526.291
Summit of ridge, 50 feet east of, in granite bowlder 2 by 1 feet; copper bolt stamped "4398"	4,398.579
Junction of North Fork and Mill creeks, 0.5 mile northwest of, in granite bowlder 12 feet north of trail; copper bolt stamped "3935"	3,935.200
Junction of Mill Creek and North Fork of Big Tujunga, near trail from latter, in granite bowlder; copper bolt stamped "3056"	3,056.473
Mill Creek, 2 miles above mouth, 20 feet from north end of wagon road, in rock on south bank of Mill Creek at point where trail goes over ridge to Big Tujunga Creek; copper bolt stamped "3463"	3,463.749

MOUTH OF MILL CREEK SOUTHWEST TO MOUTH OF NORTH FORK OF TUJUNGA CREEK (SINGLE SPUR).

Vertical Falls, on North Fork, 35 feet in height, in ledge of rock on north side of creek, about 6 feet above water and 20 feet north of falls; bronze tablet stamped "2879"	2,879.728
Falls where North Fork empties into Big Tujunga Creek, 40 feet south of, in granite bowlder 6 by 5 by 4 feet on north side of North Fork where drift log is lodged; copper bolt stamped "2671"	2,670.977

END OF WAGON ROAD ON MILL CREEK, SOUTHEAST ACROSS RIDGE ALONG TRAIL, TO TUJUNGA CREEK; THENCE UP CREEK TRAIL, TO SOUTHEAST CORNER SEC. 5, T. 2 N., R. 11 W. (SINGLE SPUR).

Wickiup Canyon, 0.3 mile east of, on south side of Big Tujunga Creek, in bowlder 4 by 6 by 2 feet in bed of stream, 25 feet south of trail and 60 feet east of canyon, where trail goes down from ridge from Mill Creek, in oak stake driven in bank marked "B M." and near dead willow tree in stream; copper bolt stamped "3266"	3,266.066
Alder Creek, in bed of, at junction with Big Tujunga, in hole drilled in bowlder 8 by 8 by 12 feet; copper bolt stamped "3415"	3,415.462
T. 2 N., R. 11 W., sec. 5, near southeast corner of, 40 feet east of trail between Barley Flats and Mount Wilson, in face of granite ledge facing Tujunga River 60 feet east of pine tree 18 inches in diameter; bronze tablet stamped "4046"	4,046.138

UP MILL CREEK, NORTHEAST OVER DIVIDE AND NORTHWEST DOWN ALISO CANYON, TO ACTON.

Divide between Mill Creek and Aliso Canyon, 10 feet east of road; iron post stamped "5030"	5,030.964
Smith's stamp mill, 250 feet east of, in bowlder 6 by 6 by 4 feet at junction of roads going up Dump and Tie canyons; copper bolt stamped "4452"	4,452.098
Big Tujunga mines and Jones ranch, intersection of roads to, 6 miles east of Acton, 18 feet south of signboard; iron post stamped "3348"	3,348.151
Acton, 3 miles south of, 30 feet from northeast corner of stone house on big ridge; copper bolt stamped "3021"	3,021.701

	Feet.
Aliso Canyon, mouth of, 2 miles east of Acton, 1 foot west of signboard; iron post stamped "2829"	2,829.711
Acton, in brick wall southeast corner of hotel; bronze tablet stamped "2700" (recovered by precise leveling)	2,700.771

ACTON, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD TO RAVENNA (RECOVERED BY PRECISE LEVELING).

Ravenna station, on east side of track, 58 feet east of door of office of station building and 3.5 feet from gum tree; iron post stamped "2468"	2,468.188

ALISO CANYON, NORTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO VINCENT (RECOVERED BY PRECISE LEVELING).

Vincent, 500 feet north of station, in corner of jog in fence, and 500 feet west of center line of sec. 22, T. 5 N., R. 12 W.; iron post stamped "3219"	3,219.258

CALABASAS 15′ (CAMULOS 30′) QUADRANGLE.

ENCINO, WEST ALONG CHATSWORTH PARK BRANCH RAILROAD, TO CANOGA; THENCE NORTH TO CHATSWORTH.

Reseda, 2.7 miles west of, 40 feet west of center of county road, near first telegraph pole west of road crossing, 50 feet south of track; iron post stamped "773 L. A."	773.859

NEAR CANOGA, SOUTHWEST ALONG ROAD, TO GRAPE ARBOR.

Calabasas, 38 feet east of northeast corner of calaboose building, at southeast corner of picket fence around vineyard, 60 feet northwest of west end of bridge; iron post stamped "928 L. A."	928.576
T. 1 N., R. 17 W., sec. 31, 4 feet north of southwest corner; iron post stamped "694 L. A."	694.558

SANTA SUSANA 15′ (CAMULOS 30′) QUADRANGLE.

FERNANDO, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO SAUGUS (RECOVERED BY PRECISE LEVELS).

San Fernando tunnel, 0.25 mile south of south end of, at south end of white fence at end of yard at section house; iron post stamped "1417" (recovered by precise line)	1,416.373
San Fernando Pass, road over tunnel, 50 feet south of north end of cut east side of wall, 4 feet above floor of road; bronze tablet stamped "1799"	1,799.437
Newhall, between tree and telegraph pole, 27 feet south of station and 30 feet from center of track; iron post stamped "1273" (recovered by precise line)	1,272.195
Saugus, 18 inches from north corner of pump house, 18 feet from center of track and 33 feet from south corner of station building; iron post stamped "1171" (recovered by precise line)	1,170.641

FERNANDO, WEST ALONG WAGON ROAD, TO CHATSWORTH PARK.

Chatsworth Park and Fernando, midway between, 5 feet south of fence corner, 37 feet south of center of road running east and west, and 45 feet east of road running north and south; iron post stamped "1031 L. A."	1,031.863

	Feet.
Chatsworth Park, at corner of Simi road and Devonshire avenue, 1 foot north from southeast corner of Santa Susana schoolhouse, 11.5 inches below base of building; bronze tablet stamped "962 L. A."	963. 154

CHATSWORTH PARK, WEST ALONG ROAD OVER SANTA SUSANA PASS, TO SIMI.

Santa Susana Pass, at summit and 50 feet north of road, 33 feet southwest of signpost, in large sandstone bowlder 4.5 feet above ground; bronze tablet stamped "1604 L. A."	1, 604. 321
Santa Susana, 30 feet southeast from southeast corner of bunk house, 165 feet southeast of section house, at corner of fence; iron post stamped "961 L. A."	961. 276

SAUGUS, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO CAMULOS.

San Francisco ranch, 81 feet east from northeast corner of house of superintendent, in northeast corner of yard, 2 feet from junction of fence lines, 15 feet west of center of road; iron post stamped "1054 L. A."	1, 053. 601
Los Angeles and Ventura counties, 3.5 feet south of iron signpost of, 6 feet south of fence line, 50 feet north of center of track, 12 feet south of county road; iron post stamped "858 L. A."	857. 773

SAUGUS, NORTH ALONG ROAD, TO ST. FRANCIS RANCH.

T. 5 N., R. 16 W., sec. 34, south side of, in northwest corner of Edw. D. Kichline's field, at foot of grade over mountain, 1 foot east of corner of fence; iron post stamped "1235 L. A."	1, 234. 801

CAMULOS QUADRANGLE.

GRAPE ARBOR, WEST ALONG ROAD, TO RUSSELL VALLEY; THENCE NORTH TO SIMI.

Russell Valley, 2 miles east of, summit of pass between Vejor and Newbury Park ranch, north side of road where ledge of sandstone appears on surface, in center of most westerly slab of sandstone 10 by 4 by 1.5 feet; bronze tablet stamped "977 L. A."	977. 431
Newbury Park ranch, in front of residence of W. H. Crowley, 30 feet south of wagon road at west corner of fence; iron post stamped "859 L. A."	859. 749
Summit of pass from Crowley's to Simi, south side of road, in flat sandstone; bronze tablet stamped "1289 L. A."	1, 289. 486
Simi, 1.3 miles southwest of, 18 feet east of marked corner of sec. 17, T. 2 N., R. 18 W., 24 feet east of center of road at fence post; iron post stamped "730 L. A."	730. 453

SIMI, NORTHWEST ALONG ROAD VIA GRIMES CANYON, TO FILLMORE; THENCE EAST ALONG SOUTHERN PACIFIC RAILROAD, TO CAMULOS.

Epworth, 39 feet east of center line of Buena Vista street, at corner of Broadway, 87 feet southeast of southeast corner of fruit packing house; iron post stamped "868 L. A."	868. 898
Grimes ranch, sec. 7., T. 3 N., R. 19 W., 600 feet southwest of house, 100 feet east of corral, 30 feet east of small dry wash, 3 feet north of gate post on wagon road; iron post stamped "642 L. A."	642. 562

	Feet.
Fillmore, 125 feet southwest of southwest corner of station, 65 feet southeast of center of railroad and highway crossing, 1.5 feet north of fence corner; iron post stamped "469 L. A."	469.914
Buckhorn, 153 feet northeast of northeast corner of station, 50 feet north of track, 3 feet west of telegraph pole; iron post stamped "599 L. A."	598.493
Camulos, 200 feet south of southeast corner of station, 2.5 feet south of northwest corner of post-office; iron post stamped "732 L. A."	731.437

FILLMORE, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO SESPE.

Brownstone, in front of station; top of north rail	448.3
Sespe, 1,300 feet north of station, 50 feet south of main entrance to San Cayetano schoolhouse, 1 foot north of fence; iron post stamped "501 L. A."	502.382
Sespe, in front of station; top of north rail	456.0

RUSSEL RANCH, WEST AND NORTH IN CONEJO VALLEY VIA POTRERO, TO SOMIS; THENCE EAST TO SIMI.

Pass from Conejo to Potrero, 150 feet west of road, on slope of rock ledge in field; bronze tablet stamped "1315 L. A."	1,315.549
Guadalasca, El Conejo, and Calleguas grants, joint corner of, 10 feet north of road, in pile of rocks, at summit of ridge; iron post stamped "778 L. A."	778.704
Somis, 8 feet south of southeast corner of fence around public school, 15 feet west of public road; iron post stamped "288 L. A."	288.460
Moor Park, 20 feet southwest of southwest corner of station, 30 feet north of center of track; iron post stamped "511 L. A."	511.960

HUENEME QUADRANGLE.

SOMIS, SOUTHWEST ALONG SOUTHERN PACIFIC RAILROAD (SOMIS BRANCH), TO SUCROSA; THENCE WEST TO OXNARD; THENCE NORTH TO MONTALVO.

Springville, 1 mile south of, in T. 2 N., R. 21 W., 90 feet south of junction of Wood and Pleasant Valley roads, 1 foot east of east corner of schoohouse; iron post stamped "53 L. A."	54.185
Oxnard, in front of station; top of south rail	50.0
Oxnard, 445 feet southwest of southwest corner of station, 1.3 feet west of west fence post; iron post stamped "48 L. A.."	48.639
Montalvo, in front of station; top of north rail	95.9
Montalvo, 225 feet northwest of station, 35 feet east of road, 1 foot south of fence, 50 feet north of center of track; iron post stamped "93 L. A."	94.133

OXNARD, SOUTH ALONG WAGON ROAD, TO HUENEME; THENCE EAST AND NORTH TO SUCROSA SIDING.

Hueneme, at junction of Market and Main streets, west side of Bank of Hueneme, in eighth row of bricks above sidewalk and second horizontal row from sidewalk; bronze tablet stamped "8 L. A."	8.494
Round Mountain, at north foot of, junction of road, 250 feet east of water trough on Conejo road, 2.5 feet west of signboard marked "Hueneme 8.75 m., Conejo county line 14.5 m., Montalvo 13 m., Saticoy 12.5 m."; iron post stamped "30 L. A."	30.338

SANTA PAULA QUADRANGLE.

SESPE, SOUTHWEST ALONG SOUTHERN PACIFIC RAILROAD (SANTA BARBARA BRANCH), TO MONTALVO.

	Feet.
Santa Paula, 100 feet south of south side of station, at southwest corner of Ojai and Santa Barbara streets; iron post stamped "288 L. A."	288.363
Santa Paula, in front of station; top of rail	290.8
Saticoy, 80 feet south of center of station, at northeast corner of park on railroad reservation; iron post stamped "149 L. A."	149.302
Saticoy, in front of station; top of north rail	149.2

SATICOY, NORTHWEST 3 MILES ALONG WAGON ROAD, TO HARMAN BARRANCA.

Harman Barranca, on west side of northeast fork of, at north end of cultivated field on east slope of hill; iron post stamped "620 L. A."	629.572

SATICOY, EAST ALONG WAGON ROAD, TO SOMIS.

Saticoy, 3.1 miles south of, at southwest corner of Santa Clara and Del Norte avenues, 60 feet west of signpost, in corner stake of ranch; 8-penny wire nail	114.54
Saticoy, 6.2 miles east of, at Center schoolhouse, in northwest corner of yard; iron post stamped "313 L. A."	313.567

SANTA PAULA, NORTH ALONG WAGON ROAD, TO SULPHUR MOUNTAIN SPRINGS; THENCE WEST TO NORDHOFF.

Sulphur Mountain Springs, 6 feet east of gate to, 50 feet north of cottage, 1 foot south of wire fence on north side of road; iron post stamped "1005 L. A."	1,005.610
Thatcher's school, 600 feet west of, 40 feet north of township corner, at southwest corner of sec. 34, T. 5 N., R. 22 W., south side of road, 6 feet east of telephone pole; iron post stamped "1323 L. A." (elevation by spur 2 miles north of main road)	1,323.516
Nordhoff, 5 feet north of southwest corner stake of schoolhouse lot, 35 feet north on center of road; iron post stamped "743 L. A."	743.389
Nordhoff, in front of station; top of rail	730.1

VENTURA QUADRANGLE.

MONTALVO, NORTHWEST ALONG SOUTHERN PACIFIC RAILROAD, TO CARPINTERIA.

Ventura, in front of station; top of north rail	48.0
Ventura, on east side of main entrance to county court-house, 2.4 feet west of northeast corner of tower, 1.4 feet above sidewalk; bronze tablet stamped "13 L. A."	14.095
Sea Cliff, in front of station; top of north rail	14.7
Punta Gorda, in front of station; top of rail	16.5
Punta Gorda schoolhouse, 600 feet east of, 100 feet west of milepost 514, in north corner of fence at road crossing, 25 feet east of road; iron post stamped "21 L. A."	22.020

VENTURA, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO NORDHOFF.

Lacrosse siding, at south end of, center of track	302.6
Lacrosse road crossing, 50 feet west of, opposite signpost marked "Matilija 8.75 m., Nordhoff 6.5 m., Santa Anna schoolhouse 3.5 m., Ventura 7.5 m."; iron post stamped "314 L. A."	314.786

	Feet.
Oakview spur, at switch stand; base of rail	481.2
Mirror Lake, south end of, 45 feet northwest of road crossing, 3 feet south of signpost marked "Matilija 5.75 m., Nordhoff 4.25 m., Ventura 10.5 m."; iron post stamped "626 L. A."	626.812
Mirror Lake; surface of water	611.4
Long Valley spur, opposite waiting room; center of track	632.9
Matilija spur, in front of waiting room; center of track	757.5

NORDHOFF, NORTHWEST ALONG WAGON ROAD, TO MATILIJA.

Matilija, 100 feet west of post-office, at east end of corral, opposite feed barn, in large rock in fence; bronze tablet stamped "955 L. A."	955.843

CASITAS SWITCH, WEST ALONG WAGON ROAD, TO CARPINTERIA.

Casitas Pass, summit of, 15 feet north of center of road, near center line of sec. 34, T. 4 N., R. 24 W.; iron post stamped "1155 L. A."	1,155.317
Shepards, 0.2 mile south of, on sec. 25, T. 4 N., R. 25 W., 2 feet north of signpost marked "County line—Ventura 18 m., Santa Barbara 17 m.," near junction of road, on northwest bank of Rincon Creek; iron post stamped "213 L. A."	213.661

PALMDALE QUADRANGLE.

MANZANA, EAST ALONG ROAD, TO FAIRMONT; THENCE SOUTH TO ELIZABETH LAKE; THENCE SOUTHEAST TO HAROLD (ALPINE).

Fairmont, 300 feet southeast of southeast corner of public schoolhouse, at southeast corner of fence; iron post stamped "2786 L. A."	2,785.588
W. A. Spencer's house, 75 feet southeast from corner of, 1 foot south of fence corner; iron post stamped "2803 L. A."	2,802.809
Pedro Andrada's house, 60 feet north of, 2 feet northeast of signboard at corner of road where it forks east and south; iron post stamped "3403 L. A."	3,402.719
Hill, on slope of, 25 feet south of road; iron post stamped "3177 L. A."	3,176.513
J. G. Ritter's house, 0.5 mile north of, 450 feet north of gate, 12 feet north of road at summit of ridge at head of valley; iron post stamped "3048 L. A."	3,047.223
Signpost marked "Alpine, 5 miles," 15 feet west of, 100 feet east of road up canyon, 200 feet south of road to Palmdale; iron post stamped "2831 LA."	2,830.299
Una Lake, sec. 3, lot 8, T. 5 N., R. 12 W., 1.5 feet southeast of southeast corner of bunk house of South Antelope Valley Irrigation Company; iron post stamped "2820 L. A."	2,819.772
Harold siding (formerly Alpine), 1.5 feet west of northwest corner of fence around railroad section house, 9 feet east of center of track; iron post stamped "2826 L. A."	2,826.028

UNA LAKE, SOUTHEAST, TO LITTLE ROCK.

East Palmdale, 0.25 mile south of, in corner of fence, 40 feet north of center of road to Little Rock from East Palmdale, in sec. 6, T. 6 N., R. 11 W., 450 feet northwest of section corner; iron post stamped "2682"	2,681.639

	Feet.
Little Rock, inside of fence at Chaplin ranch, 54 feet east from post-office building and 25 feet east of quarter corner on west side of sec. 13, T. 5 N., R. 11 W.; iron post stamped "2910"	2,910.249

ELIZABETH LAKE, SOUTHWEST, TO ST. FRANCIS RANCH.

P. Andrade's house, 60 feet north of, 2 feet northeast of signboard at forks of road; iron post stamped "3403 L. A."	3,402.558
Juan de Cellis's house, 1 mile south of, at turn of road on top of first hill south of bridge; iron post stamped "2604 L. A."	2,603.774
Canyon, at turn of road in, 15 feet below small ditch where it turns around point of hill; iron post stamped "1913 L. A."	1,912.124

TEJON QUADRANGLE.

AT SEC. 11, T. 5 N., R. 16 W.

T. 5 N., R. 16 W., sec. 11, 1 mile south of St. Francis ranch, 40 feet west of road, on small flat, 5 feet east of cottonwood tree; iron post stamped "1600 L. A."	1,598.988

CASTAC, NORTHWEST ALONG WAGON ROAD AND TRAIL VIA CASTAC, PIRU, AND GRAPEVINE CREEKS TO ROSE STATION.

Carmichael's ranch, 1.5 feet west of northwest corner of fence, on north side of lane; iron post stamped "1172 L. A."	1,171.538
Victor Cordova's residence, west side of, at west corner of fence around garden, 500 feet north of wagon road, on mesa above creek; iron post stamped "1457 L. A."	1,456.750
House of Frank S. Randolph, 0.3 mile from, 12 feet east of trail to Oak Flats, at summit of ridge from Castac Creek; iron post stamped "2807 L. A."	2,806.940
Spring Creek, 1,500 feet north of where it empties into Piru Creek, 45 feet north of trail where it turns north up Piru Canyon, on flat side of rock 6 by 2 by 4 feet; bronze tablet stamped "2060 L. A."	2,059.276
Bainbridge's house, 250 feet northeast of, sec. 34, T. 7 N., R. 18 W., at north corner of fence around hog corral, at south end of and 30 feet east of center of wagon road to house; iron post stamped "2307 L. A."	2,306.266
Alamo ranch, in jog of fence around house of M. C. Bailey; iron post stamped "2796 L. A."	2,795.270
German ranch, Charles Schliesmayer's ranch, 1.5 feet west of corner, at intersection of fence lines, 45 feet south of road; iron post stamped "3463 L. A."	3,462.718
Tejon Pass, at summit, 6 feet south of brush fence and 40 feet north of wagon road; iron post stamped "4230 L. A."	4,229.933
Los Angeles and Kern counties; 6 penny wire nail in notch on post marking line	3,750.18
Los Angeles and Kern counties, 2.5 feet north of line post; iron post stamped "3744 L. A."	3,744.104
Fort Tejon, in front of gatepost at entrance to residence of superintendent of Castac ranch, 45 feet west of wagon road; iron post stamped "3174 L. A."	3,173.480
Rose station, 0.5 mile south of top of grade from, 20 feet east of road at top of hill where road runs across low place to the south; iron post stamped "2132 L. A."	2,131.529

	Feet.
T. 10 N., R. 19 W., near northwest corner sec. 4, 12 feet south of gate across road, 10 feet east of center of road, 2 feet south of post 6 by 8 inches; iron post stamped "1085 L. A."	1,084.684

LUBEC, WEST TO SOLDIERS' HOME CAMP.

Soldiers' Home Camp, opposite deserted ranch house, 4 feet west of fence line, 6 feet south of wagon road; iron post stamped "4471"	4,471.721

GERMAN, EAST ALONG ROAD, VIA QUAIL AND NEENACH, TO MANZANA.

McKenzie's house, 160 feet northeast of northeast corner of, at northeast corner of intersection of fences, 50 feet south of road; iron post stamped "3393 L. A."	3,392.690
La Liebre ranch, at corner of fence where road turns to east, 0.5 mile west of brick house on county road; iron post stamped "3091 L. A."	3,090.936
Henry Hatch's ranch (Vala Vista), at residence, 2 feet east of gate, in front of picket fence; iron post stamped "3039 L. A."	3,039.018
Manzana, opposite driveway from main road to post-office and store of A. E. Silvey, on east side of road, 1 foot south of fence post; iron post stamped "2870 L. A."	2,869.559

MOUNT PINOS QUADRANGLE.

MATILIJA, NORTH ALONG TRAIL, TO OZENA.

Matilija Creek, north side of, 50 feet east of junction with Upper North Fork, west side of trail, at mouth of canyon, on sandstone bowlder, 3.5 by 2.5 feet; bronze tablet stamped "1589 L. A."	1,590.189
Ortega Hill, at summit; on ridge between North Fork of Matilija River and Sespe River, on rock bowlder 2.5 feet by 3 feet; bronze tablet stamped "4970 L. A."	4,971.315
Sespe River, 450 feet east of small cabin, mouth of canyon, 25 feet east of where trail leaves to go over Pine Mountain, in ledge of sandstone; bronze tablet stamped "4144 L. A."	4,145.021
Pine Mountain, 3 miles south of Ozena; at summit of ridge, 6 feet east of trail, in block of hard rock 18 by 24 inches; bronze tablet stamped "5314 L. A."	5,314.963
Ozena, 10 feet southwest of southwest corner of post-office, 10 feet north of wagon road; iron post stamped "3576 L. A."	3,576.691

OZENA, NORTHEAST ALONG WAGON ROAD, TO SOLDIERS' HOME CAMP NEAR LUBEC.

Ozena, 6 miles east of, at junction of canyons, 20 feet east of road where road to Lockwood Valley turns north, north end of grade; iron post stamped "4017 L. A."	4,017.421
Cuyama and Lockwood valleys, summit of ridge divide between, 8 feet north of wagon road; iron post stamped "5516 L. A."	5,516.643
Griffin, 1,200 feet northwest of residence of S. Snedden, 2 feet south of corner of fence at intersection, at turn of road; iron post stamped "4871 L. A."	4,871.830
Griffin and Cuddy's ranches, summit of divide between, 25 feet east of road; iron post stamped "5556 L. A."	5,556.014

OZENA NORTHWEST ALONG WAGON ROAD TO SEC. 19, T. 9 N., R. 24 W.

	Feet.
T. 8 N., R. 24 W., sec. 8, south side of, 1.2 feet north of county-line post marked "C. L. 25" on north side, "V" on east side, and "S. B." on south side, 60 feet south of road; iron post stamped "3100 L. A."	3,101.168
T. 9 N., R. 24 W., sec. 19, 600 feet south of, George Root's adobe house, north edge of road, in corner of fence at junction; iron post stamped "2749 L. A."	2,750.005

SANTA BARBARA SPECIAL QUADRANGLE.

CARPINTERIA, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO SANTA BARBARA.

Carpinteria, 30 feet east of southeast corner of station, 35 feet north of main track, 2 feet east of telegraph pole; iron post stamped "11 L. A."	11.710
Serena, at switch stand; top of rail	28.3
Ortega siding, in front of signboard; top of south rail	73.8
Summerland, 30 feet east of east end of station, 1 foot east of telegraph pole, 60 feet north of center of track; iron post stamped "52 L. A."	52.789
Summerland, in front of station; top of rail	52.8
Miramar; top of rail	23.6
Santa Barbara, on block 192, at west corner of City Hall; iron post stamped "37 L. A."	38.011
Santa Barbara, Victoria street, in front of station; top of north rail	66.7
Santa Barbara, 1.3 miles northwest of Victoria street station, in corner of fence at private road crossing, 300 feet east of east end of through cut, 40 feet north of track, 30 feet east of lone cottonwood tree; iron post stamped "128 L. A."	129.237

GOLETA SPECIAL QUADRANGLE.

SANTA BARBARA, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO CAPITAN.

Irma siding, opposite signboard; top of rail	158.4
Goleta, 70 feet east of windmill frame, 120 feet south of center of track, 2 feet east of corner of fence, east side of road; iron post stamped "43 L. A."	43.530
Elwood, in front of station; top of north rail	85.6
Elwood, 1.7 miles west of, 660 feet east of milepost 358, at road crossing, 20 feet north of track, near fence; iron post stamped "57 L. A."	58.212
Naples, in front of station; top of north rail	96.2

SANTA BARBARA, WEST ALONG ROAD, TO NEAR GOLETA; THENCE NORTH OVER SAN MARCOS PASS, TO COLD SPRING CANYON.

Mrs. D. Pico Ruis's house, 45 feet north of northeast corner, 100 feet southwest of road to Laurel Springs, 2 feet south of sandstone bowlder 7 by 6 by 6 feet; iron post stamped "1526 L. A."	1,527.336

GOLETA SPECIAL (SANTA YNEZ 30′) QUADRANGLE.

AT COLD SPRING CANYON.

	Feet.
Cold Springs Hotel, south side of driveway to, on first terrace on west side of main road; iron post stamped "1630 L. A."	1,631.431

SANTA YNEZ 30′ QUADRANGLE.

COLD SPRING CANYON, NORTHWEST, TO NEAR SANTA YNEZ.

San Marcos ranch, 100 feet south of old abode ruin, 30 feet west of road, 20 feet east of gate, in corner of fence; iron post stamped "842 L. A."	842.818
San Marcos ranch, 5.8 miles northwest of, 5 feet north of road, at down-grade turn to cross canyon; iron post stamped "696 L. A."	696.911

SAN RAFAEL, NORTHEAST ALONG TRAIL, TO WASIOJA SCHOOL.

San Rafael Mountain; summit of trail	4,374
Davy Brown's cabin, 80 feet southwest of southwest corner of, 100 feet south of creek crossing, 30 feet west of northwest corner of trail, at northwest corner of fence, in slab of sandstone 2 by 2 feet; bronze tablet stamped "2038 L. A."	2,038.767
Manzana schoolhouse, 4.8 miles southeast of, on top of ridge, about 7 feet south of trail, where creek makes big bend to north, in slab of sandstone; bronze tablet stamped "1511 L. A."	1,512.300
Manzana schoolhouse, east of, at foot of slope, 60 feet west of road, 600 feet south of mouth of Manzana Creek, in sandstone bowlder, 6 by 5 by 3 feet; bronze tablet stamped "1163 L. A."	1,164.013
Williams Canyon, mouth of, on west bank, 750 feet north of adobe house, 30 feet south of road, in block of sandstone 18 by 30 inches; bronze tablet stamped "1489 L. A."	1,490.344
Williams Canyon, 5.1 miles northwest of mouth of, on north edge of trail, at mouth of small ravine, on top of cement gravel bowlder 8 by 5 inches by 4 feet; bronze tablet stamped "3009 L. A."	3,009.980

SEC. 19, T. 9 N., R. 24 W., NORTHWEST ALONG CUYAMA RIVER ROAD AND OVER RIDGE, TO WASIOJA.

T. 10 N., R. 25 W., sec. 33, intersection of east and west and north and south fence lines, 150 feet south of road; iron post stamped "2404 L. A."	2,405.320
Cuyama ranch, at turn of road to house, 300 feet southwest of southwest corner of adobe house, 100 feet east of southwest corner of cattle corral, in southwest corner of fence; iron post stamped "2180 L. A."	2,180.912
Agua Caliente ranch, 2.2 miles west of east boundary of, 30 feet north of road, on flat on Agua Caliente ranch; iron post stamped "1935 L. A."	1,935.792
Green Canyon, mouth of, foot of slope, 15 feet east of road at turn up canyon where road leaves Cuyama River and goes over mesa to Wasioja; iron post stamped "1784 L. A."	1,784.899
Wasioja schoolhouse (3 miles east of Wasioja), 1.5 feet west of northeast corner of building; iron post stamped "2352 L. A."	2,352.663
Wasioja, 1 foot north of northwest corner of residence of J. B. Mallory, in sec. 7, T. 10 N., R. 28 W.; iron post stamped "2303 L. A."	2,393.950

LOMPOC 30′ QUADRANGLE.

CAPITAN, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO GAVIOTA.

	Feet.
Capitan, 1.8 miles east of, 1 foot west of milepost 352, 25 feet north of track; iron post stamped "109 L. A."	109.720
Capitan siding, in front of signboard; top of north rail	75.3
Morella siding; top of north rail	47.1
Tajiquas siding, 135 feet east of northeast corner of fence around railroad section house lot, 200 feet north of center of track, 50 feet south of road, 30 feet west of gate in fence; iron post stamped "59 L. A."	59.813
Gaviota, in front of telegraph office; top of south rail	94.9
Gaviota, 125 feet south of southwest corner of station, 80 feet south of center of track, against fence on edge of bluff above beach; iron post stamped "94 L. A."	93.869

GAVIOTA, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO JALAMA.

Santa Anita switch, at road crossing; center of track	64.2
Santa Anita switch, 1 mile west of, 355 feet east of signpost, 185 feet west of milepost 334, 20 feet south of track; iron post stamped "48 L. A."	48.281
Gata switch, at road crossing; top of rail	51.9
Concepcion, 200 feet northwest of station, 6 feet east of northeast support of water tank; iron post stamped "112 L. A."	112.427
Concepcion, in front of station; center of track	111.4

GAVIOTA, NORTH ALONG WAGON ROAD, TO LOS OLIVOS.

Las Cruces, 1 foot south of northeast corner of fence around public school; iron post stamped "339 L. A."	339.043
Nojoqui Pass, summit of, 25 feet south of road, on bench; iron post stamped "879 L. A."	879.296
Old Santa Ynez mission, 35 feet northeast of gate at entrance to grounds, south edge of road, at corner of fence; iron post stamped "495 L. A."	495.415

LOS OLIVOS, NORTHWEST ALONG PACIFIC COAST RAILWAY, TO SANTA MARIA; THENCE NORTHEAST, ALONG HIGHWAY, TO SUEY RANCH.

Los Olivos, 1 foot north of south corner of public school building, 1 foot west of brick foundation; iron post stamped "836 L. A."	836.150
Zaca, in front of station; base of west rail	774.7
Calkin siding, west end of, 1 foot south of fence, 60 feet northeast of road crossing; iron post stamped "939 L. A."	939.141
Wigmore siding, in front of signboard; base of south rail	751.3
Los Alamos, road crossing at station; top of rail	569.
Los Alamos public school, in northwest corner of lot, 1 foot east of junction of fence lines; iron post stamped "569 L. A."	569.324
Los Alamos, 4 miles west of, at point of curve near telegraph pole, 31 feet south of track; iron post stamped "425 L. A."	425.279
Harris, in front of station; top of east rail	308.3
Harris, 1.5 miles north of, top of bank, through cut, 30 feet east of track, 1 foot west of fence, between two crossings of creek; iron post stamped "378 L. A."	378.370
Blake, in front of station; top of rail	400.7
Divide, in front of station; top of rail	509.2

	Feet.
Graciosa schoolhouse, 15 feet south of northeast corner of fence around, 150 feet west of road crossing at track; iron post stamped "314 L. A."	314.411
Lake View, in front of station; top of east rail	253.8
Santa Maria, in front of station; top of east rail	203.4
Santa Maria, 140 feet east of east side of Pacific Coast Railway Company's station, 2 feet north of corner post of fence at northeast corner of Chapel street and Railroad reservation; iron post stamped "204 L. A."	204.496
Suey ranch house, at entrance to grounds, 8 feet east of gatepost at junction of fence lines, 20 feet west of center of road; iron post stamped "377 L. A."	377.067

SANTA YNEZ MISSION, EAST VIA SANTA YNEZ, TO FERRY; THENCE NORTH, VIA SANTA AGUEDA CREEK, TO SAN RAFAEL MOUNTAIN.

Santa Ynez, at ferry crossing, 30 feet west of road, 15 feet south of tree to which cable is fastened, on flat; iron post stamped "522 L. A."	523.646
Santa Agueda (St. Agnes) Creek, 5 miles north of junction with Santa Ynez River, line between Donovan ranch and College pasture, 20 feet west of gate in fence, 85 feet west of creek; iron post stamped "807 L. A."	809.016
Los Olivos, 7.5 miles northeast of, 2.7 miles west of Birabent's house, at junction of small canyon below grade that turns north; iron post stamped "1501 L. A."	1,502.976
Birabent's house, 1.7 miles east of, 30 feet south of wagon road, on ridge near summit; iron post stamped "2982 L. A."	2,984.066

LOS ALAMOS, SOUTHWEST ALONG COUNTY ROAD VIA SANTA RITA (STEWART), TO LOMPOC; THENCE SOUTHEAST TO LAS CRUCES.

Los Alamos, 6.3 miles southwest of, on saddle between two ridges, on west side of road, 25 feet south of gate in fence; iron post stamped "1476 L. A."	1,476.629
Stewart (Santa Rita), 0.8 mile west of, in southwest corner of field, on north side of road, at corner of lane to barnyard of D. Streeter; iron post stamped "415 L. A."	415.297
Purisima Mission Building, 0.3 mile south of ruins of, at southwest corner of road where it turns south, opposite county tank and water trough; iron post stamped "112 L. A."	112.210
Lompoc, at station of Southern Pacific Railroad, in front of telegraph office; top of south rail	94.9
Lompoc, at southwest corner of Railroad avenue and Eighth street, in northeast corner of fence around public schoolhouse lot, 36 feet south of main track; iron post stamped "93 L. A."	93.588
Lompoc, 4.6 miles southeast of, south side of gate, on east side of main road, in east corner of fence at intersection of fences; iron post stamped "238 L. A."	237.971
San Julian ranch, 0.9 mile west of house, in corner of fence, 30 feet south of gate; iron post stamped "603 L. A."	603.065
Las Cruces, 4.1 miles northwest of, 30 feet north of road, 40 feet south of telephone pole, 2.5 feet south of white stake No. 24, in mound of rocks; iron post stamped "927 L. A."	926.752

SANTA YNEZ MISSION, WEST ALONG ROAD TO STEWART.

	Feet.
Santa Rita (Stewart), 4.3 miles southeast of, road at culvert, 6 feet west of road, at summit; iron post stamped "552 L. A."	552.022

SANTA MARIA, SOUTHEAST VIA GAREY AND CAT CANYON, TO LOS ALAMOS.

Santa Maria, 5.8 miles southeast of, 75 feet south of small frame house on land owned by Mr. Blockman, 50 feet south of poplar tree 18 inches in diameter, 15 feet southwest of right turn in road, 2 feet southwest of fence corner; iron post stamped "322 L. A."	321.920
Garey, 60 feet north and 10 feet east of schoolhouse, 6 feet southwest of northeast corner of fence around schoolhouse; iron post stamped "376 L. A."	376.063
Garey, 4.8 miles southeast of, 70 feet northeast of Hopedale schoolhouse, 150 feet south of road, 20 feet west of fence; iron post stamped "596 L. A."	596.067
Garey, 8 miles southeast of, 12 feet southeast of road at summit; iron post stamped "1252 L. A."	1,252.001

GUADALUPE QUADRANGLE.

SANTA MARIA, WEST ALONG COUNTY ROAD, TO GUADALUPE.

Bennett schoolhouse, in southeast corner of school yard, 8 feet from corner of fence; iron post stamped "144 L. A."	144.197

GUADALUPE, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO JALAMA.

Guadalupe, 0.25 mile south of station, 100 feet north of point where switch leaves for sugar factory, 30 feet west of switch target at south end of Guadalupe yards, 50 feet north of county road, at south end of fence; iron post stamped "84 L. A."	84.063
Waldorf, 3 feet north of signpost; iron post stamped "201 L. A."	201.668
Casmalia, 100 feet south of, south side of track, 30 feet west of wagon road; iron post stamped "291 L. A."	291.092
Narlon sign post, 3 feet north of, east side of track; iron post stamped "129 L. A."	129.200
Lompoc Landing, 60 feet west of crossing signpost, at road crossing, in corner of fence; iron post stamped "158 L. A."	158.026
Surf, 300 feet north of station, north side of wagon road, near southwest point of Y, 6 feet northeast of crossing signpost; iron post stamped "36 L. A."	35.600
Surf, in front of station; center of track	46.0
Weser, opposite signpost; center of track	133.1
Honda, signpost; center of track	108.6
Honda, 900 feet south of signpost, 300 feet north of south end of switch, 3 feet southwest of railroad crossing signpost; iron post stamped "110 L. A."	110.738
Arguello, at signpost; top of rail	173.7
Arguello, 30 feet east of east end of switch, 30 feet north of track, opposite white post; iron post stamped "161 L. A."	160.789
Sudden, west end of gate leading into station, 250 feet west of telegraph office; iron post stamped "85 L. A."	84.588

	Feet.
Jalama Creek, 50 feet north of north end of bridge over, 30 feet west of track, opposite large red water tank; iron post stamped "96 L. A."	95.748
Jalama, switch signpost; center of track	102.4

NARLON, EAST ALONG ROAD, TO HARRIS.

Narlon, 5 miles southeast of, south of San Antonio Creek, at foot of Barker's grade on Lompoc road, at southeast corner of wire fence, in bowlder 24 by 36 by 36 inches above ground; aluminum tablet stamped "95 L. A."	95.462

SURF, EAST ALONG SOUTHERN PACIFIC RAILROAD (LOMPOC BRANCH), TO LOMPOC.

Baroda, 3.5 miles southeast of, 30 feet west of county windmill No. 11, southwest corner of railroad crossing inclosure; iron post stamped "31 L. A."	30.080

BALLARAT, FURNACE CREEK, AND PILOT PEAK, 1° QUADRANGLES (WHICH INCLUDE VARIOUS 30′ QUADRANGLES NOT MENTIONED); BARSTOW 30′ QUADRANGLE; AND RANDSBURG 15′ QUADRANGLE.

INYO, KERN, AND SAN BERNARDINO COUNTIES.

The elevations in the following list are based upon the precise line Mohave, Cal., to Lida, Nev., of the United States Geological Survey and upon an elevation at Barstow determined by the United States Coast and Geodetic Survey in 1906 by precise leveling from San Diego.

The leveling was done mostly by Mr. L. F. Biggs, levelman, in 1907. Part of the work on Randsburg quadrangle was done in 1900 under Mr. L. C. Fletcher, topographer, by Mr. C. C. Ward, levelman, republished from Bulletin No. 185 corrected, and additional work on Pilot Peak 1° quadrangle and part of the work on Ballarat 1° quadrangle was done in 1905 by Messrs. Biggs and Ress Philips, and in 1906 by Mr. Philips. The 1906 and 1907 lines were run single with prism level and yard rods.

The bench marks are stamped serially or with figures of elevation, or both, and with datum letters. Those stamped " J " on Randsburg quadrangle are stamped with figures of elevation about 7 feet too great, and those of 1905–6, having been stamped prior to office reduction, are stamped about 1 to 4 feet too low.

BARSTOW 30′ QUADRANGLE.

BARSTOW, NORTH 6 MILES ALONG ROAD TOWARD BALLARAT.

	Feet.
Barstow, 215 meters west of Atchison, Topeka and Santa Fe station, in fence corner of land of Charles O'Donnell; top of stone post (U. S. Coast and Geodetic Survey B. M. H_3 1906)	2,101.707

	Feet.
Barstow, 2.6 miles north of, 20 feet west of road; iron post stamped "B 2386 1906"	2,386.487
Barstow, 6 miles north of, at Forks of roads; iron post stamped "B 2695 1906"	2,691.094

PILOT PEAK 1° QUADRANGLE.

POINT 6 MILES NORTH OF BARSTOW, TO BALLARAT.

Barstow, 9 miles north of, 10 feet north of 18-inch Yucca; iron post stamped "B 2892 1906"	2,892.427
Barstow, 12.5 miles north of, summit 30 feet west of road; iron post stamped "B 3960 1907"	3,960.261
Barstow, 15 miles north of, 20 feet east of road; iron post stamped "B 3679 1907"	3,679.390
Barstow, 18.2 miles north of, 20 feet east of road; iron post stamped "B 3306 1907"	3,306.461
Barstow, 21.3 miles north of, 20 feet east of road; iron post stamped "B 3221 1907"	3,220.762
Barstow, 24.8 miles north of, 20 feet east of road, 200 feet south of dry lake; iron post stamped "B 3006 1907"	3,005.657
Copper City, 7.3 miles south of, 20 feet east of road; iron post stamped "B 3035 1907"	3,035.070
Copper City, 3.5 miles south of, 20 feet east of road; iron post stamped "B 3291 1907"	3,291.006
Copper City House, 100 feet east of, iron post stamped "B 4001 1907"	4,000.932
Copper City, 3.2 miles north of, on summit 15 feet west of road; iron post stamped "4402 B 1907"	4,402.326
Granite Wells, junction of roads, large bowlder; aluminum tablet stamped "B 3936 1907"	3,939.564
Granite Wells, 2.7 miles north of, 40 feet east of road, sandstone ledge; aluminum tablet stamped "B 3404 1907"	3,403.590
Granite Wells, 6 miles north of, 40 feet east of road, bowlder; aluminum tablet stamped "B 2719 1907"	2,718.586
Granite Wells, 8.9 miles north of, 20 feet east of road; iron post stamped "B 2370 1907"	2,270.292
Granite Wells, 12.2 miles north of, 20 feet east of road; iron post stamped "2276 B 1907"	2,175.828
Lone Willow, 10 miles south of, 15.3 miles north of Granite Wells, 20 feet east of road; iron post stamped "B 2203 1907"	2,103.810
Lone Willow, 6 miles south of, 20 feet east of road; iron post stamped "2121 B 1907"	2,021.245
Lone Willow, 2.6 miles east of, at junction of road to Lone Willow; iron post stamped "2016 1907 B"	1,915.696
Lone Willow, 2.5 miles north of, 10 feet east of road, large bowlder; aluminum tablet stamped "B 1932 1907"	1,832.120
Lone Willow, 5.4 miles north of, 20 feet east of road at junction of road to Ballarat; iron post stamped "B 1786 1907"	1,685.479
Lone Willow, 8.1 miles north of, 200 feet north of large bowlder, 30 feet west of road; iron post stamped "B 1907 1632"	1,631.582
Lone Willow, 10.1 miles north of, 10 feet east of road; bowlder, tablet stamped "B 1907 1427"	1,427.216
Lone Willow, 12.7 miles north of, 17.1 miles south of Ballarat, 20 feet east of road; iron post stamped "B 1907 1229"	1,228.940

	Feet.
Ballarat, 14 miles south of, 20 feet west of road; iron post stamped "B 1907 1098"	1,098.300
Ballarat, 10.9 miles south of, 20 feet east of road; iron post stamped "B 1907 1059"	1,059.047
Ballarat, 7.6 miles south of, at junction of road, 10 feet east of road; iron post stamped "B 1907 1051"	1,051.027

BARSTOW, ALONG BALLARAT ROAD EAST, TO POINT 3.3 MILES EAST OF WINDGATE PASS.

Windgate Pass, at summit, 10 feet east of road, 2.5 miles east of junction of road; iron post stamped "B 1977 1907"	1,976.778
Windgate Pass, 3.3 miles east of, 20 feet north of road; iron post stamped "B 1925 1907"	1,924.983

FREEMAN, SOUTHEASTERLY TO RANDSBURG; THENCE EASTERLY TO GRANITE WELLS.

Freeman, 400 feet south of, 20 feet west of road, on hillside, south side of Walker Canyon; iron post stamped "3379 B"	3,381.335
Freeman, 5 miles east of, 150 feet north of road, on point 300 yards west of wash, 10 feet east of section corner, large bowlder; tablet stamped "B 2705 1907"	2,706.763
Freeman, 123 miles east of, 30 feet south of road, ledge; tablet stamped "B 2975 1907"	2,977.063
Willow Springs, at summit of divide south of, 15 feet west of road, 10 feet from granite bowlder; iron post stamped "J 4116"	4,109.639
Garden station, 3.3 miles south of, at junction of road to Willow Springs, 300 feet west of road; volcanic bowlder; aluminum tablet stamped "B 3512 1907"	3,513.244
Randsburg, 5.1 miles north of, 25 feet northwest of junction of Old Borax road to Garlock, 20 feet northwest of road; iron post stamped "3010 J"	3,002.810
Randsburg, 1.5 feet west of door of butcher shop (stone building), 1 foot above ground; bronze tablet stamped "3530 J"	3,522.737
Johannesburg, 2.5 feet northwest of platform of station, north side of track; iron post stamped "3544 J"	3,536.333
Johannesburg, 4.4 miles east of, on summit of divide 20 feet west of road; iron post stamped "3326 J"	3,317.945
Ts. 29 and 30 S., Rs. 41 and 42 E., 10 feet southeast of common corner; iron post stamped "2823 J"	2,814.281
Granite Wells, 9 miles southwest of, 30 feet south of Blackwater Well, granite ledge flush with ground; tablet stamped "B 3520 1907"	3,521.627
Granite Wells, 7.3 miles southwest of, on summit 20 feet north of road, large bowlder; tablet stamped "B 3952 1907"	3,952.817
Granite Wells, 1.5 miles south of, 39.8 miles north of Barstow, 10 feet east of road; point on small bowlder painted "3947 USBM"	3,946.900

FREEMAN, NORTHWEST TO WALKERS PASS.

Walkers Pass, 5 miles southeast of, 50 feet west of road, 200 feet east of spring, granite bowlder; aluminum tablet stamped "BB"	4,033.279

POINT 6.6 MILES NORTH OF MOUNT VERNON MILL, SOUTHWEST TO INDIAN WELLS NORTH OF FREEMAN.

Mount Vernon Mill, 4 miles north of, 350 feet west of spring, 20 feet northwest of road, in top of large granite bowlder; bronze tablet stamped "5323 B 1905 24"	5,326.752

	Feet.
Mount Vernon Mill, 1.1 miles north of, 5 feet south of road, 40 feet west of Vurless cabin, in large granite bowlder; bronze tablet stamped "4276 B 1905"	4,279.602
Mount Vernon Mill, 2.25 miles west of, at mouth of Mount Springs Canyon, 20 feet west of road, in large bowlder; bronze tablet stamped "3388 B"	3,392.108
Mount Vernon Mill, 5.8 miles southwest of, 15 feet west of road, in cropping of granite bowlder; bronze tablet stamped "2631 B"	2,635.801
Mount Vernon Mill, 8.8 miles southwest of, 25 feet west of road; iron post stamped "2273 B"	2,277.960
Desert Well, 1 mile east of, 35 feet north of road, in borax flat in ledge; bronze tablet stamped "2199 B"	2,203.775
Desert Well, 2 miles south of, 100 feet east of road, on south side of dry lake; iron post stamped "2209 B"	2,214.008
Desert Well, 5.2 miles southwest of, 50 feet east of road; iron post stamped "2225 B"	2,229.966
Indian Wells, 5.5 miles northeast of, 30 feet east of road, in alkali flat; iron post stamped "2236 B"	2,241.178
Indian Wells, 2.5 miles north of, 15 feet west of road; iron post stamped "2402 B"	2,407.195
Indian Wells, 300 feet north of, 10 feet west of road; iron post stamped "F 16"	2,740.161

RANDSBURG 15′ QUADRANGLE (PILOT PEAK 1° QUADRANGLE).

JOHANNESBURG WEST TO RANDSBURG.

Johannesburg, in front of station; top of rail	3,537.3
Johannesburg, 25 feet northwest of platform of station, north side of track; iron post stamped "3544 J" (recovered by Biggs, 1907)	3,536.333
Randsburg, 1.5 feet west of door of butcher shop (store building), 1 foot above ground; bronze tablet stamped "3530 J" (recovered by Biggs, 1907)	3,522.737

RANDSBURG, NORTH TO GARDEN STATION.

Randsburg, 5.1 miles north of, 25 feet northwest of junction of old borax road to Garlock, 20 feet northwest of road; iron post stamped "3010 J" (recovered by Biggs, 1907)	3,002.810
Garden station, 1 mile northeast of, sec. 18, T. 28 S., R. 41 E., Mount Diablo meridian, 50 feet northwest of road, 4 feet east of northwest corner of section; iron post stamped "3024 J." (This bench mark is north of Randsburg 15′ quadrangle on Pilot Peak, 1° quadrangle)	3,016.325

IN T. 28 S., R. 40 E., NORTHWEST TO SUMMIT OF DIVIDE SOUTH OF WILLOW SPRINGS.

T. 28 S., R. 40 E., sec. 34, 300 feet west of junction of roads, in volcanic bowlder; aluminum tablet stamped "3512 B 1907" (set by Biggs, 1907)	3,513.244
Willow Springs, at summit of divide south of, 15 feet west of road 10 feet from granite bowlder; iron post stamped "4116 J" (recovered by Biggs, 1907)	4,109.639

GARDEN STATION, SOUTH VIA SUMMIT DIGGINGS, TO JOHANNESBURG.

Little Dry Lake, summit of divide at south end of, 30 feet east of road; iron post stamped "3220 J"	3,212.190

RANDSBURG, SOUTHEAST TO BLACK HAWK MINE; THENCE NORTH TO JOHANNESBURG.

	Feet.
Black Hawk Mine, on ridge 750 feet north of, 30 feet north of road and 50 feet from junction with road to Stringer; iron post stamped 3706 J "	3,698.691

JOHANNESBURG, EAST VIA SKILLING WELLS ROAD, TO TOWNSHIP CORNER; THENCE NORTHEAST TO SOUTHWEST CORNER SEC. 29, T. 29 S., R. 42 E.

Johannesburg, 4.4 miles east of, on summit of divide 20 feet west of road; iron post stamped "3326 J" (recovered by Biggs, 1907)	3,317.945
T. 30 S., R. 42 E., 10 feet southeast of northwest corner sec. 6; iron post stamped "2823 J" (recovered by Biggs, 1907)	2,814.281
T. 29 S., R. 42 E., 5 feet northeast of southwest corner sec. 29; iron post stamped "2812," (single spur)	2,803.223

JOHANNESBURG, SOUTH ALONG LINE OF RANDSBURG RAILROAD (SINGLE SPUR LINE).

St. Elmo, 50 feet west of switch stand, iron post stamped "3184 J."	3,176.109
St. Elmo, 3.84 miles south of, 30 feet west of track; iron post[a] stamped "2984 J"	2,975.880

QUADRANGLE EAST OF PILOT PEAK.

NEAR WINDGATE PASS, NORTHEASTERLY TO POINT 22 MILES FROM WINDGATE PASS.

Windgate Pass, 6.3 miles east of, 50 feet east of road, large bowlder; tablet stamped "B 1863 1907"	1,863.300
Windgate Pass, 9.6 miles east of, 20 feet east of road; iron post stamped "B 1730 1907"	1,730.316
Windgate Pass, 13.3 miles northeast of, 30 feet east of road; iron post stamped "B 1610 1907"	1,609.840
Windgate Pass, 15.5 miles northeast of, 20 feet east of road; iron post stamped "B 1907 1278"	1,278.004
Windgate Pass, 17.5 miles northeast of, 10 feet east of road, bowlder; tablet stamped "B 1907 930"	929.394
Windgate Pass, 21.1 miles north of, 200 feet north of road, large bowlder; aluminum tablet stamped "B 1907 480"	479.238

FURNACE CREEK 1° QUADRANGLE.

POINT 22 MILES NORTHEAST OF WINDGATE PASS, NORTH THROUGH DEATH VALLEY, TO STATE LINE NEAR DAYLIGHT SPRINGS.

Bennett's well, 16 miles south of, 20 feet east of road; iron post stamped "B 1907 —215"	—215.156
Bennett's well, 13.1 miles south of, 20 feet east of road; iron post stamped "B 1907 —224"	—224.676
Bennett's well, 10 miles south of, 20 feet east of road; iron post stamped "B 1907 —235"	—235.087
Bennett's well, 7.2 miles south of, 40 feet east of Mesquite Wells; iron post stamped "B 1907 —244"	—224.460
Bennett's well, 4.2 miles south of, 20 feet east of road; iron post stamped "B 1907 —248"	—248.546
Bennett's well, 20 feet east of; iron post stamped "B 1907 —276"	—266.393
Bennett's well, 3.5 miles north of, 20 feet east of road; iron post stamped "B 1907 —260"	—250.230
Bennett's well, 7 miles north of, 20 feet east of road; iron post stamped "B 1907 —253"	—243.929

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[a] This bench mark is south of Randsburg 15' quadrangle on Pilot Peak 1° quadrangle.

	Feet.
Bennett's Well, 10.1 miles north of, 20 feet east of road; iron post stamped "B 1907 —263"	—253.412
Furnace Creek ranch, 8.6 miles south of, 20 feet east of road, in borax flat; iron post stamped "B 1907 —284"	—274.180
Furnace Creek ranch, 5.9 miles south of, 20 feet east of road; iron post stamped "B 1907 —233"	—223.173
Furnace Creek ranch, 2.8 miles south of, 20 feet west of road; iron post stamped "B 1907 —227"	—217.576
Furnace Creek ranch, 300 feet south of house at road forks; iron post stamped "B 1907 —188"	—178.357
Furnace Creek ranch, 4.6 miles north of, 20 feet east of road; iron post stamped "B 1907 —262"	—253.389
Furnace Creek ranch, 7.4 miles north of, 400 feet west of road; stone monument (corner of North Coleman borax deposit), top painted "USBM —261"	—251.44
Furnace Creek ranch, 8.6 miles north of, 20 feet east of road; iron post stamped "B 1907 —258"	—248.608
Furnace Creek ranch, 12.4 miles north of, 60 feet north of road; iron post stamped "B 1907 1"	10.753
Furnace Creek ranch, 16 miles north of, 50 feet east of road, sandstone ledge; aluminum tablet stamped "B 1907 669"	678.290
Furnace Creek ranch, 21 miles north of, at junction of road to Stovepipe, 20 feet east of road, rock ledge; aluminum tablet stamped "B 1907 2253"	2,263.047
Daylight Springs, 3.5 miles south of, 20 feet east of road, rock ledge; aluminum tablet stamped "B 1907 3117"	3,127.138
Daylight Springs, 0.2 mile east of, on summit 20 feet east of road; iron post stamped "B 1907 4307"	4,317.380

ROAD FORK 11 MILES NORTH OF FURNACE CREEK RANCH, NORTHWEST 11 MILES TOWARD STOVEPIPE.

Furnace Creek ranch, 12 miles north of, 9 miles southeast of Stovepipe, 20 feet east of road; iron post stamped "B 1907 —231"	—231.630

STATE LINE, WEST TO FURNACE CREEK RANCH.

Kings Springs, 12 miles west of, at junction of roads; iron post stamped "B 1907 2101"	2,101.736
Kings Springs, 13.2 miles west of, 1.7 miles north of Nelson's mill No. 2, 20 feet west of road; iron post stamped "B 1907 2117"	2,117.545
Nelson's well No. 2, 200 feet west of; iron post stamped "B 1907 2180	2,179.977
Nelson's well No. 2, 4.5 miles west of, 20 feet south of road; iron post stamped "B 1907 2572"	2,572.655
Summit, 1.5 miles east of, 20 feet south of road, bowlder; aluminum tablet stamped "B 1907 2864"	2,864.839
Summit, 20 feet south of road; iron post stamped "B 1907 3041"	3,041.742
Smith Tank, 5.6 miles east of, 20 feet south of road, rock ledge; aluminum tablet stamped "B 1907 2701"	2,701.536
Smith Tank, 1.4 miles east of, at junction of Greenwater road, 20 feet north of road; iron post stamped "B 1907 1938"	1,939.069

	Feet.
Smith Tank, 2.1 miles west of, 8.1 miles east of Furnace Creek, 30 feet south of road, bowlder; aluminum tablet stamped "B 1907 1330"	1,331.062
Furnace Creek, 2.5 miles east of, at spring (head of Furnace Creek), 40 feet north of road; iron post stamped "B 1907 283"	283.463

BALLARAT 1° QUADRANGLE.

BENCH MARK ON FURNACE CREEK QUADRANGLE (9 MILES SOUTHEAST OF STOVEPIPE), NORTHWEST VIA STOVEPIPE, TO MESQUITE SPRING.

Stovepipe, 6.3 miles southeast of, on summit 20 feet east of road; iron post stamped "B 1907 —68"	—68.098
Stovepipe, 3.6 miles southeast of, 20 feet north of road; iron post stamped "B 1907 —90"	—90.741
Stovepipe, 150 feet east of store, at junction of roads; iron post stamped "B 1907 —49"	—49.118
Stovepipe, 3.3 miles northwest of, 30 feet east of road; iron post stamped "B 1907 —13"	—13.539
Stovepipe, 5.6 miles northwest of, 20 feet west of road, bowlder; tablet stamped "B 1907 —29"	—29.794
Surveyors Well, 7.5 miles north of, 1.2 miles south of Lost Wagons; 50 feet east of road, large white bowlder; aluminum tablet stamped "B 1907 +373"	372.700
Mesquite Spring, 400 feet south of, at junction of roads, bowlder; tablet stamped "B 1907 1739"	1,738.824

STOVEPIPE, SOUTHWEST TO EMIGRANT WASH; THENCE SOUTH TO BALLARAT.

Stovepipe, 2.5 miles southwest of, 20 feet north of road; iron post stamped "B 1907 —46"	—46.078
Stovepipe, 6.3 miles southwest of, 20 feet north of road; iron post stamped "B 1907 0000"	—0.566
Stovepipe, 9.6 miles southwest of, 20 feet north of road; iron post stamped "B 1907 637"	636.331
Stovepipe, 12.5 miles southwest of, 6.7 miles north of, Emigrant Spring, 20 feet north of road; iron post stamped "B 1907 1542"	1,541.757
Emigrant Spring, 4.2 miles north of, 20 feet north of road; iron post stamped "B 1907 2380"	2,379.264
Emigrant Spring, 1.7 miles north of, 40 feet east of road; iron post stamped "B 1907 3199"	3,198.574
Emigrant Spring, 100 feet south of restaurant at station; iron post stamped "B 1907 4046"	4,045.131
Emigrant Spring, 4.3 miles south of, 3.1 miles north of Summit, 20 feet east of road; iron post stamped "B 1907 4899"	4,898.715
Summit between Death and Panamint valleys, 20 feet west of road; iron post stamped "B 1907 5321"	5,320.034
Summit, 2.9 miles southwest of, 5.6 miles east of Wild Rose, 20 feet north of road; iron post stamped "B 1907 5021"	5,020.272
Wild Rose, 2.2 miles north of, 20 feet west of road; iron post stamped "B 1907 4462"	4,461.826
Wild Rose, 20 feet west of road; iron post stamped "3617 B 1907"	3,616.896
Wild Rose, 3 miles south of, 14.7 miles north of Ballarat, 20 feet east of road; iron post stamped "B 1907 2496"	2,495.773

	Feet.
Ballarat, 11.7 miles north of, 20 feet west of road; iron post stamped "B 1907 1989"	1,988.023
Ballarat, 8.2 miles north of, 200 feet south of well; iron post stamped "B 1907 1104"	1,103.198
Ballarat, 4 miles north of, 20 feet east of road; iron post stamped "B 1907 1082"	1,080.982
Ballarat, 300 feet north of post-office, large bowlder; aluminum tablet stamped "KEELER 1906 1069"	1,069.587
Ballarat, in front of post-office; iron post stamped "1066"	1,066.729

BALLARAT, SOUTH 3.8 MILES.

Ballarat, 1.6 miles south of, 20 feet east of road, bowlder; aluminum tablet stamped "B 1907 1054"	1,054.200
Ballarat, 3.8 miles south of, 20 feet east of road; iron post stamped "B 1907 1049"	1,049.193

KEELER, SOUTHEAST ALONG ROAD, TO DARWIN.

Keeler, 3.4 miles southeast of, 25 feet east of road; iron post stamped "3629 B"	3,631.009
Keeler, 6.4 miles southeast of, 80 feet northeast of road, dark volcanic bowlder; aluminum tablet stamped "3923 B"	3,924.927
Keeler, 9.6 miles southeast of, 0.5 mile south of summit, 25 feet east of road, volcanic bowlder; aluminum tablet stamped "4298 B"	4,299.545
Keeler, 12.8 miles southeast of, 1,000 feet east of stone corral, 20 feet north of road; iron post stamped "4551 B"	4,553.026
Darwin, 8.4 miles northwest of, 25 feet north of road, black volcanic bowlder; aluminum tablet stamped "4878 B"	4,880.389
Darwin, 5.3 miles northwest of, 25 feet south of road; iron post stamped "5269 B 1905"	5,290.907

DARWIN, SOUTH AND SOUTHWEST VIA COSO HOT SPRINGS, TO LITTLE LAKE (A POINT ON FARMER'S PRECISE LINE).

Darwin, 2 feet from southeast corner of post-office; iron post stamped "4746 B"	4,748.596
Darwin, 2.5 miles south of, 25 feet west of road, 15 feet west of pipe line, granite rock; aluminum tablet stamped "4787 B"	4,789.915
Darwin, 5.7 miles south of, 25 feet west of road, granite bowlder; aluminum tablet stamped "5425 B"	5,427.476
Coso, 200 feet north of, 200 feet north of spring, 200 feet northwest of road, summit of cliff of bowlders; aluminum tablet stamped "5829 B"	5,831.378
Coso, 2.8 miles southwest of, 1,700 feet north of Cole Spring, 25 feet south of road, granite bowlder; aluminum tablet stamped "6413 B"	6,415.332
Coso, 6.6 miles southwest of, 20 feet west of road, on summit west of volcanic mountain, volcanic rock; aluminum tablet stamped "6251 B"	6,253.873
Coso Hot Springs, 3.3 miles northeast of, 40 feet west of road at east side of large gulch, granite bowlder; aluminum tablet stamped "4398 B"	4,392.066
Coso Hot Springs, 1,000 feet west of, granite rock; aluminum tablet stamped "3632 B"	3,634.850

	Feet.
Coso Hot Springs, 4.1 miles west of, 20 feet south of road, at top of steep pitch volcanic rock; aluminum tablet stamped "4059 B"	4,061.598
Coso Hot Springs, 8 miles west of, 60 feet southeast of road, opposite small crater, granite bowlder; aluminum tablet stamped "3406 B"	3,408.636
Little Lake, 1.7 miles north of, 50 feet west of road, summit of bowlder; aluminum tablet	3,329.511

DARWIN, SOUTH ALONG ROAD, TO POINT 5 MILES SOUTH OF MILLSPAUGH; THENCE SOUTH 6 MILES TO POINT 6.6 MILES NORTH OF MOUNT VERNON.

Darwin, southwest corner of post-office; iron post stamped "4746 B"	4,748.596
Darwin, 3 miles southeast of, 15 feet west of road, granite bowlder; aluminum tablet stamped "4463 B"	4,465.944
Darwin, 6.4 miles southeast of, 25 feet east of road at junction; iron post stamped "4446 B"	4,449.055
Darwin, 10.5 miles southeast of, 25 feet east of road, granite bowlder; aluminum tablet stamped "4815 B"	4,818.215
Darwin, 12.3 miles southeast of, 20 feet west of road, granite bowlder; bronze tablet stamped "5324 B"	5,327.071
Darwin, 15 miles southeast of, 60 feet west of Frank Steward's house; iron post stamped "5722 B"	5,725.383
Mount Vernon Mill, 12.4 miles north of, 5 miles west of Millspaugh, 25 feet east of road; iron post stamped "5685 B 1905"	5,688.170
Mount Vernon Mill, 9.3 miles north of, 50 feet west of road, in large granite bowlder; bronze tablet stamped "5842 B 1905"	5,845.037
Mount Vernon Mill, 6.6 miles north of, 15 feet east of road, near summit, in large granite bowlder; bronze tablet stamped "5884 B"	5,887,468

FIVE MILES WEST OF MILLSPAUGH, EAST ALONG STAGE ROAD VIA MILLSPAUGH, TO BALLARAT.

Millspaugh, 1 mile west of, 20 feet south of road, in large bowlder; aluminum tablet stamped "6073 KEELER"	6,074.448
Millspaugh, 100 feet west of post-office, 75 feet south of well, in large outcropping bowlder; aluminum tablet stamped "6157 KEELER"	6,157.805
Millspaugh, 3 miles southeast of, 0.2 mile east of spring and stage station, 12 feet north of road, in top of granite bowlder; bronze tablet stamped "4857 KEELER"	4,858.355
Millspaugh, 5.5 miles southeast of, in canyon 100 feet west of high black cliff, in large outcropping bowlder; aluminum tablet stamped "3517 KEELER"	3,517.921
Ballarat, 8.7 miles northwest of, on broad slope overlooking Ballarat and Panamint valleys, below mouth of Shepherds Canyon, 20 feet north of road, in large granite bowlder; aluminum tablet stamped "2460 KEELER 1905"	2,461.208
Ballarat, 4.6 miles west of, 15 feet north of road, in outcropping bowlder; aluminum tablet stamped "1387 KEELER"	1,389.160
Ballarat, 2.4 miles west of, 40 feet west of junction of Ballarat and Bullfrog roads, in large borax flat; iron post stamped "KEELER 1045"	1,045.700
Ballarat, 300 feet north of post-office, 20 feet north of road, in large outcropping bowlder; aluminum tablet stamped "1069 KEELER"	1,069.587
Ballarat, 20 feet south of post-office; iron post stamped "1066 KEELER" set in cubic yard of concrete	1,066.729

MESQUITE SPRINGS NORTH TO STATE LINE MONUMENT NO. 82.

	Feet.
Mesquite Springs, 4.8 miles north of, opposite Grapevine Springs, 20 feet west of road, large bowlder; tablet stamped "B 1907 2078"	2,078.164
Sand Spring, 50 feet southwest of, bowlder flush with ground; tablet stamped "B 1907 3127"	3,127.681
Sand Spring, 4 miles north of, 200 feet east of road; California-Nevada State-line monument No. 82, top of painted post	3,741.714
Sand Spring, 4 miles north of, State-line monument No. 82, on bowlder; tablet stamped "B 1907 3739"	3,739.866

KERNVILLE AND OLANCHA QUADRANGLES.

INYO, KERN, AND TULARE COUNTIES.

The elevations in the following list are based upon precise levels run in 1905 from Mohave north along stage road to Keeler, thence north along Carson and Colorado Railway, and also upon a bench mark at Caliente. The bench marks at Mohave and Caliente are on a precise-level line of 1902, and the heights now accepted are derived by an adjustment of this line made in January, 1907, taking into account rod error discovered upon rerunning, and precise leveling of 1906 from San Diego to Mohave, the new value at Mohave being 2 feet higher than that formerly accepted.

The leveling along the Kern Valley is the result of a single primary line run in 1905 by Mr. C. H. Semper, levelman, corrected for rod error by 0.0004 foot per vertical foot decreasing differences and bearing no other adjustment except to spur west from mouth of Coyote Creek to Hackett trail, Kaweah quadrangle, on account of a remaining closure of +1.8 feet and to the section north from Coyote Creek to Mount Whitney on account of a closure of —1.5 feet on the mean results of Farmer's and Shannon's primary lines from Mount Whitney station.[a]

The other leveling on Olancha quadrangle, from Olancha north, was done in 1905 by Mr. L. F. Biggs, levelman, and that on Kernville quadrangle east from Isabella to Walkers Pass was done in 1906 by Mr. Biggs. The work was all done under the direction of Mr. R. B. Marshall, geographer.

The standard bench marks are stamped with the year and figures of elevation as determined when the line was run, which are mostly incorrect.

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[a] The bench marks of Semper's line falling upon other quadrangles are elsewhere inserted as follows: Caliente (p. 104), Greenhorn (p. 103), Kaweah (p. 107), and Mount Whitney (p. 99).

OLANCHA QUADRANGLE.

OLANCHA, NORTH ALONG ROAD ON WEST SIDE OF OWENS LAKE, TO POINT 8 MILES SOUTH OF LONE PINE.

	Feet.
Olancha, in front of post-office; iron post stamped "F 31"	3,649.391
Olancha, 4 miles north of, top of hill 20 feet west of road, granite bowlder; aluminum tablet stamped "3644 B"	3,642.661
Cottonwood, 1 mile south of, 40 feet east of road, granite bowlder; aluminum tablet stamped "3678 B"	3,676.092
Lone Pine, 14 miles south of, 2 miles north of Cottonwood, top of hill, 40 feet west of road, in rock; aluminum tablet stamped "3750 B"	3,748.490
Lone Pine, 11 miles south of, 50 feet east of road, granite bowlder; aluminum tablet stamped "3691 B"	3,689.402
Lone Pine, 8 miles south of, 50 feet west of road at top of hill, granite bowlder; aluminum tablet stamped "3691 B"	3,689.580

ROCK CREEK, SOUTH ALONG KERN RIVER, TO COYOTE CREEK.[a]

Rock Creek, 100 feet south of, at top of bank of creek, west margin of trail, large rock; aluminum tablet stamped "6966 G 1905 5S"	6,969.098
Big Arroyo, 125 feet south of, 10 feet west of trail, 15 feet west of 4-foot cedar tree, large rock; aluminum tablet stamped "6662 G 1905 4 S"	6,664.410
Kern River, junction of trail down Coyote Creek with trail along Kern River, 60 feet south of Coyote Creek, west face of large granite rock; aluminum tablet stamped "6456 G 1905 3 S"	6,458.117

COYOTE CREEK, SOUTH ALONG KERN RIVER, TO TROUT MEADOW; THENCE WEST ALONG JORDAN TRAIL TO LLOYD; THENCE VIA LOWER PEPPERMINT MEADOWS AND SUCKER FLAT, TO DRY MEADOWS.

Kern Lake, surface of water, August, 1905	6,232.7
Coyote Creek, 5.3 miles south of, 100 feet north of foot of hill leading up to Trout Meadow, 600 feet south of stone wall fence across trail, in rock ledge; aluminum tablet stamped "5786 G 1905 1 S"	5,788.933
Trout Meadow, at junction of trail to Kern Flat and trail to Dry Meadows, 275 feet north of McIntyre's cabin, 25 feet east of trail, west face of large rock; aluminum tablet stamped "6119 G 1905 2 S"	6,121.123
Little Kern River, 2.8 miles south of, 750 feet south of summit of mountain, 20 feet west of trail, leading down to Lloyds Meadow, in face of large rock; aluminum tablet stamped "6839 G 1905"	6,841.084
Lloyds Meadow, at Soda Spring, top of rock over Soda Water Flow; aluminum tablet stamped "5527 G 1905 4 S"	5,529.571
Lower Peppermint Meadow, southeast end of trail which enters small dry canyon and dense scrub oak, 15 feet west of trail, face of large rock; aluminum tablet stamped "5196 G 1905 5 S"	5,198.642
Dry Meadows, at south end of, 20 feet east of trail leading to Mat Flynn Canyon, 160 feet north of trail crossing Dry Meadow Creek, west face of very large granite rock; aluminum tablet stamped "4341 G 1905 6 S"	4,344.208

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[a] Line crosses Kern River at south end of Upper Funston.

KERN RIVER, WEST VIA COYOTE AND RIFLES CREEKS, TO GREAT WESTERN DIVIDE.

	Feet.
Great Western Divide, at summit, trail leading south, top of large rock; aluminum tablet stamped "10033 G 1905 2 S"	10,033.664

KERNVILLE QUADRANGLE.

DRY MEADOW, SOUTH VIA ANGEL CAMP AND KERN RIVER, TO FAIRVIEW; THENCE ALONG TRAIL AND HIGHWAY FOLLOWING KERN RIVER, TO HAVILAH.

Kern River, junction of second Dry Meadow Creek with Kern River, 230 feet north of junction, in north wall of dry creek; aluminum tablet stamped "3765 G 1905 7 S"	3,768.028
Fairview, 150 feet directly east of Fairview Camp, 40 feet east of top of river bank, top of large granite bowlder; aluminum tablet stamped "3516 G 1905 8 S"	3,519.659
Kern River, 3 miles south of, 0.5 mile north of old corral, 25 feet east of trail, northwest face of large rock, 8 by 8 by 7 feet; aluminum tablet stamped "3122 G 1905 9 S"	3,126.051
Kernville, 6.3 miles north of, at Chico ranch, 85 feet south of south margin of house, 30 feet west of fence, 15 feet north of ditch, north face of large rock; aluminum tablet stamped "2767 G 1905 10 S"	2,771.192
Kernville, 3.1 miles north of, 960 feet south of Frank Apalatea's ranch, on west margin of road, 15 feet west of fence line, 55 feet north of fence corner, top of rock; aluminum tablet stamped "2631 G 1905 11 S"	2,634.929
Kernville, southeast corner of A. Brown & Co.'s store; aluminum tablet stamped "2565 G 1905 12 S"	2,569.015
Hot Springs, 1.9 miles south of, Kern River Flume, north end of concrete bent foundation east margin of road; aluminum tablet stamped "2487 G 1905 14 S"	2,491.264

ISABELLA, EAST VIA ONYX, TO WALKER PASS.

Isabella, on road to Death Valley, 105 feet northeast of northeast corner of Methodist Church, 8 feet north of road, top of large rock; aluminum tablet stamped "G 1905 13 2521" (Semper's)	2,525.326
Isabella, 3 miles east of, sec. 22, T. 26 S., R. 33 E., 20 feet south of road at rocky point, slate ledge; aluminum tablet stamped "B. B. 1906 1 2554"	2,555.587
Isabella, 7 miles east of, sec. 20, T. 26 S., R. 34 E., 2 feet north of fence south of road, 1,000 feet east of cottonwood trees, granite rock, flush with ground; aluminum tablet stamped "B. B. 2 2617"	2,618.291
Isabella, 9 miles east of, sec. 22, T. 26 S., R. 34 E., 1.2 miles west of Weldon, 250 feet north of cemetery, 10 feet north of road, granite bowler; aluminum tablet stamped "B. B. 1906 3 2635"	2,637.024
Weldon, 2.6 miles east of, sec. 18, T. 26 S., R. 35 E., 10 feet east of road, in saddle west of rocky point, in granite bowlder; aluminum tablet stamped "B. B. 1906 4 2686"	2,688.367
Onyx, 0.8 mile east of, sec. 4, T. 26 S., R. 35 E., 100 feet east of northeast corner of field, 20 feet south of road, granite rock; aluminum tablet stamped "B. B. 1906 5 2746"	2,747.971
Onyx, 7 miles east of, sec. 30, T. 25 S., R. 36 E., opposite Power's house, 20 feet south of road, in granite rock; aluminum tablet stamped "13 B 1906 6 2893"	2,895.527

	Feet.
Onyx, 9.2 miles east of, near quarter corner east side of sec. 29, T. 25 S., R. 36 E., 10 feet south of road, granite bowlder; aluminum tablet stamped "B. B. 1906 7 3145"	3.147.096
Onyx, 12 miles east of, sec. 23, T. 25 S., R. 36 E., 0.5 mile north of canebrake, on grade 20 feet west of road in canyon, granite rock; aluminum tablet stamped "B. B. 1906 8 3745"	3,746.956
Onyx, 15 miles east of, near southeast corner sec. 36, T. 25 S., R. 36 E., east side of creek, 20 feet east of forks of road, granite rock; aluminum tablet stamped "B. B. 1906 9 4327"	4,329.372
Walker Pass, summit of, sec. 17, T. 26 S., R. 37 E., 18 miles east of Onyx, 15 feet east of road, granite rock; aluminum tablet stamped "B. B. 1906 10 5245"	5,248.321

BISHOP, LONG VALLEY, MOUNT GODDARD, AND MOUNT WHITNEY QUADRANGLES.

INYO, MONO, AND TULARE COUNTIES.

The elevations in the following list are based upon precise leveling by R. A. Farmer, in 1905, corrected to accord with an elevation at Mohave determined by an adjustment made in January, 1907. Additional elevations on Bishop and Mount Whitney quadrangles on precise lines, Mohave to Laws and Alvord to Oasis are given in another list, pages 11–12.

The leveling was done in 1905 under Mr. R. B. Marshall, geographer, mostly by Mr. L. F. Biggs, levelman. The work on Mount Whitney quadrangle includes a double line from Mount Whitney station west to summit of Mount Whitney run by Messrs. R. A. Farmer, topographer, and M. D. Shannon, levelman, and a single line thence to and down the Kern River run by Mr. C. H. Semper, levelman. The work on Long Valley quadrangle includes work of 1898 by Mr. C. R. Smith, levelman.

MOUNT WHITNEY QUADRANGLE.

MOUNT WHITNEY STATION, WEST ALONG WAGON ROAD AND TRAIL TO SUMMIT OF MOUNT WHITNEY.

	Feet.
Mount Whitney station, southeast corner of, spike in base of telegraph pole. (This from precise line from Keeler to Law)	3,689.754
Lone Pine, in front of post-office; iron post stamped "3728 B 1905"	3,726.617
Stone House, 200 feet south of, southwest of creek, granite bowlder, 20 by 8 by 7 feet, 10 feet south of road; aluminum tablet stamped "4519 B 1905"	4,518.188
Lone Pine Creek canyon, mouth of, 400 feet east of falls, south of trail, in face of rock 20 by 10 by 6 feet; aluminum tablet stamped "6670 B 1905"	6,668.877
Hunters Camp ground, 20 feet south or trail, at bottom of steep pitch to the lakes, rock 10 by 6 feet and 5 feet out of ground; aluminum tablet stamped "8373 B 1905"	8,371.495
Summit of divide of Sierra Nevada Mountains where Lone Pine trail crosses, 20 feet north and west of trail, in granite wall; aluminium tablet stamped "13337 B 1905"	13,335.095

	Feet.
B. M. No. 35 by Semper, Mount Whitney, on south slope of junction of Lone Pine and Crabtree creeks trail; rock on top, marked "13766"	13,766.729
Mount Whitney, highest point of summit, in large rock 6.5 feet south and 5 feet west of center of monument; aluminum tablet one-half inch thick, 4.5 inches wide and 7 inches long, engraved as follows: "U. S. Geological Survey, Charles D. Walcott, Director, Latitude 36° 44′ 44″, Longitude 118° 17′ 29″, Elevation above sea, 14,501, 1905"	14,500.737

MOUNT WHITNEY, WEST ALONG TRAIL, TO CRABTREE MEADOW; THENCE NORTHWEST TO KERN RIVER; THENCE SOUTH DOWN KERN RIVER TO ROCK CREEK.

Crabtree Meadow, at junction of trail to Mount Whitney, Kern River, and Whitney Creek, top of very large rock; aluminum tablet stamped "10330 G 1905 7 S"	10,332.569
East Fork of Kern River, 2.4 miles north of, on cut-off trail, 30 feet northeast of crossing of small creek, south margin of trail, a north face of large bowlder in small meadow; aluminum tablet stamped "9837 1905 6 S"	9,838.983

LONE PINE, SOUTH ALONG ROAD 8 MILES.

Lone Pine, in front of post-office; iron post stamped "3727 B"	3,726.617
Lone Pine, 5 miles south of, 100 feet south of gulch, 20 feet west of road; iron post stamped "3711 B"	3,709.849

LONE PINE, NORTH ALONG ROAD, TO INDEPENDENCE; THENCE EAST TO CITRUS.

Lone Pine, 4 miles north of, 60 feet east of road, granite bowlder; aluminum tablet stamped "B"	3,723.462
Lone Pine, 7 miles north of, 20 feet east of road; iron post stamped "B"	3,811.899
Independence, 5.5 miles south of, 800 feet north of Shepherd's house, 50 feet west of road, in bowlder; aluminum tablet stamped "3873 B"	3,871.899
Independence, 2 miles south of, top of hill 100 feet west of road, in bowlder; aluminum tablet stamped "B"	3,941.878
Citrus, in front of station; iron post stamped "F 10"	3,766.400

INDEPENDENCE, NORTH ALONG ROAD, TO ABERDEEN.

Independence, in west wall of court-house; aluminum tablet stamped "B"	3,924.790
Independence, 4.5 miles north of, 15 feet west of road, 400 feet south of house, granite bowlder; aluminum tablet stamped "3891 B"	3,889.696
Independence, 7.5 miles north of, 20 feet west of road; iron post stamped "3868 B"	3,867.352
Independence, 10.5 miles north of, 60 feet west of road; 500 feet north of stream crossing, 0.5 mile west of Eaton's house, in volcanic rock; aluminum tablet stamped "3933 B"	3,931.947
Aberdeen, 2.8 miles southwest of, 2 miles north of Eaton's house, east side of road, volcanic rock; aluminum tablet stamped "3864 B"	3,862.978

BISHOP QUADRANGLE.

NEAR ABERDEEN, NORTH ALONG ROAD, TO BIG PINE; THENCE EAST TO ALVORD.

	Feet.
Big Pine, 12.3 miles south of, 1 mile north of Bower's house, 20 feet west of road, volcanic rock; aluminum tablet stamped "3870 B"	3,868.581
Big Pine, 7.8 miles south of, under window in front of Fish Spring schoolhouse; iron post stamped "3936 B"	3,934.648
Big Pine, 6.3 miles south of, 100 feet west of south end of pond, volcanic rock; aluminum tablet stamped "3888 B"	3,887.659
Big Pine, 3.3 miles south of, 500 feet northwest of Rheinackle's house, 150 feet west of road, volcanic rock; bronze tablet stamped "3934 B"	3,932.802
Big Pine, 4 feet north of schoolhouse; iron post stamped "4003 B"	4,002.108
Alvord, in front of station; iron post stamped "F 19"	3,930.130

BIG PINE, NORTH ALONG ROAD, TO BISHOP; THENCE EAST TO LAWS.

Big Pine, 2 miles north by 2 miles west of, west side of road at cliff of rocks, bowlder; aluminum tablet stamped "3982 B"	3,980.749
Big Pine, 6.5 miles northwest of, near quarter corner east side of sec. 36, T. 8 S., R. 33 E., 60 feet west of road, bowlder; aluminum tablet stamped "4037 B"	4,036.016
Valley schoolhouse, 3.5 miles north of, common corner of secs. 32 and 33, T. 7 S., and secs. 4 and 5, T. 8 S., R. 34 E., 0.25 mile south of Butler schoolhouse, 600 feet west of road; iron post stamped "4046"	4,045.236
Bishop, 2 miles south by 1 mile west of, 300 feet west of canal, at stone post; iron post stamped "4319 B"	4,318.783
Bishop, Fred. H. Bulpitt's store, under front window, in stone wall; aluminum tablet stamped "4148 B"	4,147.311
Laws, 100 feet east of station; iron post stamped "25 F"	4,114.583

MOUNT GODDARD QUADRANGLE.[a]

WEST AND NORTHWEST OF LAWS.

Laws, 10.7 miles west of, 1,000 feet west of Fred Meger's house, west side of road, granite bowlder; aluminum tablet stamped "B 4422 1905 B 2"	4,420.872
Laws, 14 miles northwest of, 2 miles south of Will Robert's ranch, 60 feet west of road, volcanic rock; aluminum tablet stamped "B 1905 B 3 4513"	4,511.245

LONG VALLEY QUADRANGLE.[a]

NORTHWEST OF LAWS TO DEADMAN HILL.[b]

Laws, 17 miles northwest of, 1 mile north of Will Robert's house near Mono Inyo County line, east side of road, volcanic rock; aluminum tablet stamped "B 1905 14 4698 B"	4,696.499

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[a] The elevations following on Mount Goddard and Long Valley quadrangles are by a single primary line, unadjusted, making a closure about 6 feet high on elevations brought from Yosemite based upon the same adjusted datum.

[b] For closure see Mount Lyell quadrangle, p. 118.

	Feet.
Laws, 21 miles northwest of, summit of Sherwin hill, 60 feet west of road, volcanic bowlder; aluminum tablet stamped "B 1905 B 6432"	6,430.273
Laws, 24.7 miles northwest of, south end of meadow, 15 feet east of road, 30 feet west of Rock Creek, granite bowlder; aluminum tablet stamped "B 1905 6815 B 16"	6,813.667
Laws, 28.5 miles northwest of, 100 feet north of Crookes Creek, north side of road, 200 feet northeast of forks of road, in volcanic rock; aluminum tablet stamped "B 1905 B 7 6786"	6,764.867
Laws, 30 miles northwest of, 200 feet east of proposed dam site, north side of river, 20 feet from water, large bowlder; aluminum tablet stamped "B 1905 B 8 6668"	6,668.274
Laws, 34 miles northwest of, 1 mile north of Eaton's house, north side of road, in bowlder; aluminum tablet stamped "B 1905 9 6834"	6,835.123
Laws, 37.5 miles northwest of, sec. 13, T. 4 S., R. 24 E., 300 feet north of Summer's gate, 200 feet north of road, large bowlder; aluminum tablet stamped "B 1905 10 7066"	7,066.379
Laws, 41.5 miles northwest of, 1 mile north of Summer's house, 300 feet south of Hot Creek, 100 feet south of road, at point of volcanic bowlders; aluminum tablet stamped "B 1905 B 11 7196"	7,196.987
Laws, 45 miles northwest of, 2 miles northwest of Casa Diablo, 60 feet west of road, bowlder; aluminum tablet stamped "B 1905 12 7571"	7,581.517
Laws, 48.5 miles northwest of, 5.5 miles northwest of Casa Diablo, summit between Hot and Deadman creeks, 200 feet north of road, volcanic rock; aluminum tablet stamped "B 1905 13 7446"	7,657.043
Laws, 52 miles northwest of, 0.75 mile north of Deadman Creek, west side of road about halfway up Deadman Hill, large bowlder; aluminum tablet stamped "B 1905 B 14 7723"	7,733.896

RUSH CREEK (MONO LAKE), SOUTHEAST TO MONO MILLS; THENCE SOUTHWEST TO CRATER RIDGE.[a]

Mono Mills road, about 3 miles southeast of where road leaves lake shore, 15 feet to right of road and about 200 feet east of foot of spur of Crater Ridge; iron post stamped "6899 O"	6,910.057
Mono Mills, in northwest corner post of sawmill; aluminum tablet stamped "7335 O"	7,346.304
Bodie-Benton wagon road, on summit between Mono Lake and Owens River drainage, 20 feet east of road; iron post stamped "7987 O"	7,998.104

BAKERSFIELD, CALIENTE, FAMOSO, AND GREENHORN 30′ QUADRANGLES; BAKERSFIELD SPECIAL AND OIL CENTER SPECIAL QUADRANGLES.

KERN AND TULARE COUNTIES.

The elevations in the following list are based upon a line of precise levels from Benicia along the Southern Pacific Railroad (which traverses all these quadrangles excepting Greenhorn and Oil Center Special) as adjusted in January, 1907.

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[a] Elevations determined from levels run in 1898 by Mr. C. R. Smith, corrected to agree with line from Laws, 6.355 feet greater than as determined from Merced.

Leveling was done on all of the above quadrangles in 1903 by Mr. L. D Ryus, levelman, and on all except Oil Center Special in 1904 by Mr. S. N. Stoner. Other work was done on Caliente and Greenhorn quadrangles in 1905 by Mr. C. H. Semper, levelman.

The work on Oil Center Special was done under the direction of Mr. A. B. Searle, topographer. The remainder was done under Mr. R. B. Marshall, geographer, in 1903 and 1905, Mr. S. N. Stoner having charge in 1904.

Each of the special maps covers portions of certain of the thirty-minute quadrangles above named, and the bench marks of this list which fall upon them are not separately specified.

BAKERSFIELD 30′ QUADRANGLE.

KERN, ALONG SUNSET BRANCH OF THE SOUTHERN PACIFIC RAILROAD, RUNNING SOUTHWEST, WEST, AND NORTHWEST, TO SEC. 36, T. 29 S., R. 25 E.

	Feet.
Kern, at station; iron post stamped "B"	421.877
T. 30 S., R. 28 E., sec. 6, southeast corner of, on west side of Union avenue road at crossing, north side of railroad right of way; iron post stamped "392 B"	392.278
T. 30 S., R. 27 E., sec. 15, southeast corner of, 1.68 miles west of Wibble Orchard, at west side of wagon road, at north edge of railroad right of way; iron post stamped "369 B"	369.209
Gosford, in front of station; top of rail	362.0
T. 30 S., R. 27 E., sec. 20, northwest corner of, 1.7 miles west of Gosford, at south side of road, opposite crossing to ranch house; iron post stamped "358 B"	358.551
T. 30 S., R. 26 E., sec. 15, near quarter corner on south side of, 1,200 feet west of milepost 328, north edge of right of way; iron post stamped "346 B"	346.813
T. 30 S., R. 26 E., sec. 7, 1.5 miles west of Stevens, 200 feet south of track, at corner of fence, 500 feet west of milepost 331, 20 feet east of gate; iron post stamped "337 B"	337.748
T. 29 S., R. 25 E., sec. 36, south of northwest corner of, on east side of county road, north edge of railroad right of way; iron post stamped "327 B"	327.610

SUNSET BRANCH, NORTH ALONG WAGON ROAD, TO RIO BRAVO SCHOOL; THENCE EAST TO SANTA FE RAILWAY.

	Feet.
T. 29 S., R. 25 E., sec. 11, near quarter corner on east side of, Rio Bravo schoolhouse, at southeast corner of yard; iron post stamped "332 B"	332.278
T. 28 S., R. 26 E., sec. 32, quarter corner on south side of, opposite north corner common to secs. 4 and 5, T. 29 S., north side of wagon road, at west edge of railroad right of way; iron post stamped "339 B"	339.643

SOUTHEASTERLY ALONG SANTA FE RAILROAD TO KERN.

	Feet.
T. 29 S., R. 26 E., sec. 14, near southeast corner, 0.25 mile east of Rosedale, 1 mile north of Rosedale post-office, west side of county road, north edge of railroad right of way; iron post stamped "360 B"	360.612

	Feet.
T. 29 S., R. 27 E., sec. 29, quarter corner on east side of, 4 miles west of Bakersfield, west side of public road, north edge of railroad right of way; iron post stamped "387 B"	387.366

ONE MILE EAST OF OIL TRIANGULATION STATION, SOUTHWEST ALONG ROAD 3 MILES; THENCE SOUTHWEST ACROSS COUNTRY TO 1 MILE SOUTHEAST OF JEWETTA.

T. 28 S., R. 27 E., sec. 25, southwest quarter of, Standard Oil Company's storage reservoirs, 1.5 miles north of, east bank of ravine, west side of Bakersfield and Poso Creek road; iron post stamped "730"	730.355

OIL TRIANGULATION STATION, SOUTHWEST ACROSS COUNTRY TO SEC. 14, T. 28 N., R. 27 E.; THENCE SOUTH TO NEAR JEWETTA.

T. 28 N., R. 27 E., at center of, sec. 14, 2 miles southwest of Oil triangulation station; iron post stamped "864"	864.260

FAMOSO 30′ QUADRANGLE.

POSO CREEK STAGE ROAD STATION, WEST DOWN POSO CREEK TO SEC. 29, T. 27 S., R. 27 E.; THENCE SOUTH TO NEAR JEWETTA.

T. 27 S., R. 28 E., sec. 31, in Poso Creek Valley, 2.8 miles west of stage station, 30 feet south of road, at bend of road; iron post stamped "593 B"	593.372
T. 27 S., R. 27 E., sec. 24, 8 miles north of Jewetta, mouth of drain, on end of spur, north side of road at point where road leaves Poso Creek bottom; iron post stamped "545 B"	545.397

GRANITE CANYON, NORTHWEST ALONG TRAIL AND RIDGE, TO MOUNT POSO (POSO TRIANGULATION STATION); THENCE SOUTH TO POSO CREEK.

Poso triangulation station; iron post stamped "1214 B"	1,214.865

GREENHORN 30′ QUADRANGLE.

AT OIL TRIANGULATION STATION.

Oil triangulation station, sec. 7, T. 28 S., R. 28 E.; tablet marking station, stamped "1205"	1,205.588

SEC. 18, T. 28 S., R. 28 E., NORTH ALONG HIGHWAY VIA MON CANYON AND GRANITE CANYON, TO POINT 2.4 MILES NORTH OF POSO CREEK STAGE STATION.

Poso Creek stage station, 0.2 mile east of, sec. 4, T. 28 S., R. 28 E., 300 feet east of water trough, 30 feet south of road at point where road enters creek bottom, 200 feet west of head of old canal; iron post stamped "633 B"	633.176
T. 27 S., R. 28 E., sec. 22, at fork of Granite Canyon, 2.4 miles north of Poso Creek, 20 feet west of bank; iron post stamped "884 B"	884.126

AT HAVILAH.

Havilah, Havilah Commercial Company building, north end, front face; aluminum tablet stamped "3160 G 1905 15 S"	3,164.223

CALIENTE 30′ QUADRANGLE.

HAVILAH, SOUTHWEST ALONG HIGHWAY FOLLOWING KERN RIVER, TO CALIENTE.

	Feet.
Havilah, 4.6 miles south of, 2,400 feet south of summit of mountain, on east margin of road, in small canyon, in large granite rock, west face; aluminum tablet stamped "4072 G 1905 16 S"	4,074.983
Walkers Basin, 0.8 mile north of, W. Rankin's ranch house, on east side of road, 10 feet west of fence, west face of large rock; aluminum tablet stamped "3335 G 1905 17 S"	3,338.629
Walkers Basin, 5.5 miles south of, 0.6 mile south of Oak Flat, 100 feet west of loop in road, on south edge of road, top of flat rock; aluminum tablet stamped "2900 G 1905 18 S"	2,903.822
Caliente, 3 miles northeast of, at fork of road to Pinto and Rankin camps, 10 feet west of road, large rock; aluminum tablet stamped "1534 G 1905 19 S"	1,538.246
Caliente, 65 feet south of milepost 335, 10 feet east of track; iron post[a] stamped "1201 B"	1,202.070

KERN, ALONG HIGHWAY NORTH VIA OIL CITY STATION, TO OIL TRIANGULATION STATION.

T. 29 S., R. 28 E., sec. 16, 2.5 miles north of Kern, 100 feet south of edge of mesa, at top of grade of road from Kern to Oil City; iron post stamped "684 B"	684.065
T. 28 S., R. 28 E., sec. 34, at quarter corner on south side of, at corner of fence, west side of road; iron post stamped "522 B"	523.492
T. 28 S., R. 28 E., sec. 21, on ridge about 1 mile north of water tank; iron post stamped "976 B"	976.927
Oil triangulation station, 1 mile southeast of, sec. 18, T. 28 S., R. 28 E., on round knob east of Mon Canyon road; iron post stamped "1133"	1,132.894

OIL CITY, NORTHWEST ALONG RAILROAD AND HIGHWAY, TO SEC. 24, T. 28 S., R. 27 E.

Oil Center schoolhouse, in southeast corner of yard; iron post stamped "634 B"	634.123
T. 28 S., R. 28 E., sec. 30, near southeast corner, 1 mile north of Peerless oil claim, on road on ridge north of Stirling oil claim, 100 feet north of house, south side of road; iron post stamped "768"	768.354

POINT 2.5 MILES NORTH OF KERN, SOUTHEAST ALONG SECOND-CLASS ROAD AND ACROSS COUNTRY, TO MILEPOST 320 ON SOUTHERN PACIFIC RAILROAD.

T. 29 S., R. 29 E., sec. 23, 3.5 feet southwest of northeast corner; iron post stamped "829 B"	829.283
Kern, 5 miles east of, sec. 30, T. 29 S., R. 29 E., 2.5 miles north of Southern Pacific Railroad, 20 feet south of road, at point where drain enters flat, east side of mouth of wash; iron post stamped "569 B"	569.471

KAWEAH AND VISALIA QUADRANGLES.

TULARE COUNTY.

The elevations in the following list are based on an iron post 1.4 miles south of Goshen on east side of Southern Pacific Railroad at margin of highway opposite milepost 242, stamped "286 B 1902" established by precise levels run from Benicia, by Mr. C. H. Semper.

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[a] Elevation adjusted January, 1907.

The leveling was mostly done in 1902 under the direction of Mr. E. C. Barnard, topographer, by Mr. W. V. Hardy, levelman. Additional work was done on both Kaweah and Visalia quadrangles, under Mr. R. B. Marshall, geographer, partly in 1904 and partly in 1905, by Mr. R. A. Farmer, topographer, and on Kaweah quadrangle alone in 1905 by Messrs. M. D. Shannon and C. H. Semper, levelmen.

VISALIA QUADRANGLE.

GOSHEN, EAST VIA SOUTHERN PACIFIC RAILROAD, TO VISALIA.

	Feet.
Goshen, 0.4 mile south of, east side of track, opposite milepost 241; spike in telegraph pole	282.66
Goshen, 3.62 miles east of, about 600 feet south of G. D. Smith's ranch house, 60 feet southeast of crossing, 30 feet south of track, north of road, 3 feet west of telegraph pole; iron post stamped "307 G"	307.046
Visalia, court-house, east entrance, at foot of steps; center of the letter "G" in the name "Gay" on cement sidewalk	330.53
Visalia court-house, at east side of steps at south entrance, in granite baluster; aluminum tablet stamped "334 G"	333.883

VISALIA, EAST ALONG COUNTY ROAD, TO LEMONCOVE.

	Feet.
Mineral King ranch house, 500 feet west of, northeast angle of road junction near corner fence post; iron post stamped "362 G"	361.850
Lemoncove, 8.87 miles west of, 60 feet southwest of crossing, near junction of railroad fence with wagon fence; iron post stamped "388 G"	388.028
Lemoncove, 4.76 miles west of, 50 feet southwest of Tom Hushback's ranch house, northeast angle of road junction, 1.5 feet southeast of southwest corner of yard; iron post stamped "420 G"	419.845
Lemoncove school, 2 feet east of, midway between north and south entrances; iron post stamped "510 G"	510.311

PORTERSVILLE, NORTHWEST ALONG HIGHWAY AND SOUTHERN PACIFIC RAILROAD, TO POINT EAST OF VISALIA.

	Feet.
Portersville school, south side of, 6 inches east of entrance, 12 inches above porch floor; aluminum tablet stamped "458 G"	458.104
Sam Bend's saloon, 1.15 miles south of, 70 feet southwest of road intersection, 30 inches east of telephone pole; iron post stamped "396 G"	396.431
Lindsay school, south side of, 24 inches east of entrance, 18 inches above ground; aluminum tablet stamped "383 G"	382.677
Exeter, 3.25 miles south of, 90 feet north of crossing, 30 inches east of railroad fence, 36 inches southeast of electric power line pole; iron post stamped "353 G"	352.697
Exeter school, north of steps at northwest entrance, in west face of granite baluster, 24 inches above ground; aluminum tablet stamped "391 G"	390.575
Exeter, in front of station; top of east rail	386.5

CROSSROADS 3 MILES WEST OF LEMONCOVE, SOUTHEAST VIA WAGON ROAD, TO YOKOHL SCHOOL.

	Feet.
James Hamilton's ranch house, 1.21 miles south of, northwest angle of road junction, near corner of fence; iron post stamped "499 G"	499.176

PORTERSVILLE, WEST ALONG HIGHWAY, TO TIPTON.

	Feet.
Portersville, 1 mile south by 1.5 miles west of, south side of road, Percell ranch; iron post stamped "433"	432.986
Poplar, 2 miles east of, 4.5 miles west by 1 mile south of Portersville, at southeast corner of road crossing, 8 feet south of telephone pole; iron post stamped "396"	396.162
Tipton, 5 miles east of, 4 miles west of Poplar, northwest corner of pasture, southwest corner of road crossing; iron post stamped "328"	328.091

KAWEAH QUADRANGLE.

LEMONCOVE, EASTERLY ALONG COUNTY ROAD VIA THREE RIVERS, TO MINERAL KING; THENCE SOUTHEAST ALONG TRAIL OVER FAREWELL GAP, TO WET MEADOWS.

T. 18 S., R. 28 E., sec. 4, 60 feet northeast of Horse Creek bridge, south side of road, 3 feet southwest of oak tree at southwest end of gate on road up Horse Creek; iron post stamped "610 G"	609.940
T. 17 S., R. 82 E., sec. 24, 1.42 miles north of Three Rivers post-office, junction of Mineral King and Giant Forest wagon roads, 155 feet southeast of Kaweah River bridge, southeast of junction, granite bed rock, 24 inches above level of road; bronze tablet stamped "816 G"	815.701
Three Rivers post-office, 5 miles northeast of, Mount Whitney Company power house, 40 feet east of, north of road, in side of large granite bowlder, 30 inches above level of road; bronze tablet stamped "1145 G"	1,145.355
Oak Grove telephone station, 120 feet north of, south of road, 30 inches east of gate; iron post stamped "2704 G"	2,704.579
Tranger's camp, 100 feet west of stream, north of road, in granite bed rock, 24 inches above level of road; bronze tablet stamped "4595 G"	4,594.853
Atwells Mills, 125 feet north of, 45 feet north of skid road, redwood stump 15 feet in diameter; 10-penny wire nail in root	6,452.214
Mineral King, 85 feet south of hotel, granite bowlder 120 by 180 inches by 30 inches high; bronze tablet stamped "7832 G"	7,831.686
Farewell Gap, quartz ledge cropping 30 inches long by 12 inches wide and 8 inches high; bronze tablet stamped "10588 G"	10,588.555
Wet Meadows, 120 feet south of junction of trail down Little Kern River with trail to Hacketts Meadow and Quinn's horse camp, 40 feet east of river, 20 feet above stream at trail crossing, west side of trail down river, granite bowlder, 30 by 36 by 12 inches; bronze tablet stamped "7924 G"	7,923.241

WET MEADOWS, ON LITTLE KERN RIVER, SOUTHWEST ALONG TRAIL VIA ENTERPRISE, TO SPRINGVILLE (DAUNT POST-OFFICE).

Quinn's horse camp, on summit west of, 25 feet northwest of junction of trail to Hacketts Meadow, granite bowlder 30 by 30 by 84 inches; bronze tablet stamped "9680 G"	9,679.275
Moses Mountain, at east foot of, at junction of trail down North Fork of Middle Fork of Tule River with trail to Enterprise Mill, about 300 feet east of river, 4 feet north of trail, granite bowlder 36 by 48 inches and 24 inches high; bronze tablet stamped "6614 G"	6,612.749

	Feet.
Enterprise Mill, 0.19 mile east of, on summit 15 feet southeast of road, granite bowlder, 48 by 96 inches and 24 inches high; bronze tablet stamped "6652 G"	6,651.033
Rancheria, 2.1 miles southeast of creek crossing, junction of road to Coburn dump, 4 feet west of road, 4 feet south of oak tree; iron post stamped "3202 G"	3,202.847
T. 20 S., R. 29 E., sec. 14, 2.7 miles south of Milo, 50 feet southwest of junction of road up North Tule River, granite bowlder 48 by 144 inches and 18 inches high; bronze tablet stamped "1391 G"	1,391.073
Springville, sec. 2, T. 21 S., R. 29 E., north side of school, midway between east and west entrance; iron post stamped "1032 G"	1,032.305

SPRINGVILLE, SOUTHWEST ALONG COUNTY ROAD, TO PORTERVILLE.

T. 21 S., R. 29 E., northwest corner of sec. 16, west side of Orange school, midway between north and south entrances; iron post stamped "745 G"	745.311
T. 21 S., R. 29 E., west side of sec. 24, 20 feet west of Citrus school, 30 inches south of gate; iron post stamped "622 G"	621.896

YOKOHL SCHOOL, EAST UP YOKOHL VALLEY AND OVER GAP, TO MILO.

T. 19 S., R. 27 E., sec. 24, Yokohl school, 70 feet southwest of, 20 feet north of road, embedded granite bowlder 36 by 72 inches and 12 inches high; bronze tablet stamped "636 G"	636.068
T. 19 S., R. 28 E., sec. 15, about 400 feet north of A. Carlson's ranch house, south of road, 30 inches east of gate; iron post stamped "991 G"	991.252
Blue Ridge, south end of, 15 feet north of road, summit on road, granite ledge; bronze tablet stamped "2675 G"	2,675.061

THREE RIVERS POST-OFFICE, SOUTH ALONG COUNTY ROAD TO CINNAMON SCHOOL (SINGLE SPUR LINE).

Cinnamon school, 50 feet northeast of, 15 feet northeast of road, in top of granite bowlder 36 by 60 inches and 30 inches high; bronze tablet stamped "1496 G"	1,496.057

SPRINGVILLE, EAST ALONG ROAD TO ELSTER'S RANCH (SINGLE SPUR LINE).

Elster's ranch house, 300 feet west of, south of Middle Fork of Tule River, south of road, 10 feet southwest of gate, granite bowlder 30 by 30 inches and 14 inches high; bronze tablet stamped "1206 G"	1,206.284

CITRUS SCHOOL, VIA COUNTY ROAD, TO FRAZIERS SCHOOL (SINGLE SPUR LINE).

T. 20 S., R. 28 E., sec. 32, Fraziers school, 18 inches east of, 18 inches south of steps at north entrance; iron post stamped "585 G"	585.419

PORTERSVILLE, EAST ALONG COUNTY ROAD, TO WORTH SCHOOL (SINGLE SPUR LINE).

T. 22 S., R. 28 E., sec. 3, Worth school, 45 feet south of, 3 feet east of gate; iron post stamped "571 G"	570.515

WET MEADOWS, SOUTHEAST ALONG LITTLE KERN RIVER, NORTH UP SHOTGUN CREEK, SOUTHEAST ALONG POISON MEADOW TRAIL, TO GREAT WESTERN DIVIDE, CONNECTING WITH WORK ON OLANCHA QUADRANGLE.

Great Western Divide, in saddle of spur running west from about 0.25 mile south of Rifle Creek, 10 feet east of Poison Meadow trail, in granite rock; aluminum tablet stamped "9046 G 1905"	9,046.100

COALINGA AND HANFORD QUADRANGLES.

FRESNO AND KINGS COUNTIES.

The elevations in the following list depend upon a bench mark on the precise-level line from Benicia at a point 0.4 mile south of Goshen, opposite milepost 241, a spike in base of telegraph pole, the adjusted elevation of which is 282.661 feet above mean sea level. The line was run in both forward and backward directions and the mean taken.

The leveling was done by Mr. W. V. Hardy, levelman, in the spring of 1903.

GOSHEN TO ALCALDE.

HANFORD QUADRANGLE.

GOSHEN, WEST ALONG WAGON ROAD, TO LEMOORE; THENCE WEST ALONG SOUTHERN PACIFIC RAILROAD, TO BENCH MARK 4 MILES WEST OF LETHENT.

	Feet.
Goshen, 6.34 miles west of, 100 feet northwest of road crossing, 50 feet north of track, 2 feet east of corner of railroad fence; iron post stamped "251 G"	251.198
Hanford, 4.58 miles northeast of, northwest angle of road intersection; iron post stamped "255 G"	254.765
Hanford, King County Court-house, east side of south entrance, in granite balusters; aluminum tablet stamped "250 G"	250.385
Armona school, 180 feet northwest of south of gate, at northwest corner of yard; iron post stamped "237 G"	237.211
Lemoore, Union High School, north side of east entrance, in foundation wall, 1 foot above surface of ground; aluminum tablet stamped "223 G"	223.199
Lethent, 60 feet northwest of barn, south of track, 2.5 feet east of telegraph milepole 267; iron post stamped "219 G"	219.135
Lethent, 4 miles southwest of, 4 feet east of telegraph milepole 271, south of track; iron post stamped "250 G"	250.118

COALINGA QUADRANGLE.

BENCH MARK 4 MILES WEST OF LETHENT, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO ALCALDE.

Huron, 4.3 miles northeast of, 50 feet south of track, 3 feet east of telegraph milepole 276; iron post stamped "306 G"	306.166
Huron school, 2.5 feet south of entrance; iron post stamped "380 G"	380.231
Arroyo Posa Jhena, 0.99 mile southwest of, 50 feet south of track, 3 feet east of telegraph milepole 285; iron post stamped "455 G"	455.147
Ora, 3.98 miles east of, 50 feet south of track, 8 feet north of wagon road, 5 feet east of telegraph milepole 290; iron post stamped "569 G"	569.216
Ora, 2.13 miles east of, 50 feet south of track, 5 feet east of telegraph milepole 292; iron post stamped "606 G"	606.101
Ora, 2.5 feet west of telegraph pole marked with name of station, south of oil tanks, 50 feet south of tracks, 2 feet north of wire fence; iron post stamped "647 G"	647.187
Coalinga, southwest end of station; iron post stamped "671 G"	671.152

	Feet.
Coalinga, 1.73 miles southwest of, in mouth of Waltham Canyon, 800 feet north of ranch house, 50 feet south of track, 10 feet northwest of road junction; iron post stamped "716 G"	716.110
Alcalde, 70 feet north of station, between station signboard posts; iron post stamped "852 G"	852.214

DUNLAP, FRESNO, KAISER, AND TEHIPITE QUADRANGLES.

FRESNO, MADERA, AND TULARE COUNTIES.

The elevations in the following list are based upon the precise line along the Southern Pacific Railroad. The line Fresno to Madera is adjusted, but the remainder of this list is unadjusted on account of excessive discrepancy in joining work brought from Goshen with that from Fresno. The leveling on the Tehipite quadrangle and on lines from Three Springs and from Millwood to Dunlap on Dunlap quadrangle are based upon an adjusted elevation at Kaweah Bridge on Kaweah quadrangle, in turn based upon an adjusted height at Goshen. The leveling on the Fresno and Kaiser quadrangles and west of Dunlap on Dunlap quadrangle are based upon adjusted elevation at Fresno.

On account of discrepancy the line Kaweah Bridge via Cedar Grove to Three Springs was rerun throughout and in some sections a third running was made. A comparison of these runnings over great differences of elevation enabled rod corrections to be determined, and gross errors to be eliminated. The corrected mean values are used.

The leveling on Kaiser quadrangle and on line Fresno to Kaiser quadrangle was done by Mr. L. D. Ryus in 1901, and to this no rod correction has been applied and no adjustment made except between Fresno and Clovis; the remainder of leveling on Fresno quadrangle was done in 1902–3 by Mr. Ryus.

The first running on lines Snow Corral to Cedar Grove in 1902 and Kaweah Bridge to Cedar Grove in 1903, and the work on lines to Dunlap from Three Springs, Horse Corral, and Fresno in 1903 was done by Mr. Ryus. The rerunning Three Springs via Cedar Grove to Kaweah Bridge was done by Mr. R. A. Farmer, topographer, in 1904–5.

Rod corrections have been applied to the Ryus 1902–3 lines at rate of 0.0001 foot per vertical foot, decreasing differences; and to Farmer's 1904 line 0.0003 foot, increasing differences.

The list as it stands contains the following breaks, to be corrected when further connections have been obtained: At Snow Corral—from Kaweah=7,119.44 feet; from Fresno=7,115.76 feet. At Dunlap—from Three Springs=1,915.38 feet; from Horse Corral=1,915.47 feet; from Fresno=1,911.93 feet.

TEHIPITE QUADRANGLE.

KAWEAH BRIDGE, NORTHEAST VIA MARBLE FORK AND HORSE CORRAL, TO CEDAR GROVE.

	Feet.
T. 16 S., R. 28 E., sec. 26, 7 miles north of Kaweah Bridge, on point of hill on grade 2 miles north of Davis ranch, in top of 5 by 6 foot rock on east side of road; bronze tablet	1,279.07
Sequoia National Park, 2,100 feet south of Cedar Creek Camp, west side of road at point of hill, in granite ledge; bronze tablet	3,789.80
Sequoia National Park, 130 feet east of Marble Fork Bridge, east of road and Marble Fork of Kaweah River on Giant Forest road, 50 feet north of small bridge over stream, in granite ledge; bronze tablet	5,161.00
Sequoia National Park, at upper crossing of Marble Fork of Kaweah River, 200 feet south of Marble Fork, 25 feet west of trail, in granite rock; bronze tablet	6,720.24
T. 14 S., R. 30 E., "J. O." Pass about 2 miles north of Clover Creek, 15 feet east of trail, 10 feet from signboard tree, in rock; bronze tablet	9,414.97
Horse Corral Meadow, sec. 32, T. 13 S., R. 30 E., at fork of King River and Millwood and Giant Forest trails, at foot of mound, in top of granite rock; bronze tablet	7,648.90

CEDAR GROVE, NORTHWEST VIA TEHIPITE, CROWN VALLEY, AND SAMPLER COW CAMP, TO SNOW CORRAL MEADOWS.

Cedar Grove Hotel, 0.25 mile east of sec. 13, T. 13 S., R. 30 E., 250 feet north of trail, 600 feet north of bridge over South Fork of King River, in granite rock, 6 feet high; bronze tablet	4,635.02
Happy Gap or Red Saddle, sec. 30, T. 12 S., R. 30 E., summit of ridge between Middle Fork and South Fork of King River, in ledge of rock 40 feet south of trail; bronze tablet	9,310.83
T. 12 S., R. 29 E., sec. 11, Tehipite Valley, 1.3 miles south of Tehipite Dome, 200 feet north of ford, west bank of Middle Fork of King River, in large rock; bronze tablet	4,085.70
Crown Valley or Collins Meadow, sec. 30, T. 11 S., R. 29 E., at junction of Tunamah and Tehipite trails, 100 feet east of Rogers corral, at Crown Valley Camp, in granite rock, 4.5 feet high, 10 feet square; bronze tablet stamped "7879 F"	7,882.69
Three Springs, 1.5 miles east of, sec. 16, T. 11 S., R. 28 E., south side of trail, 200 feet west of small meadow, at rocky point 2 miles west of creek, 700 feet east of summit of ridge, in granite ledge; bronze tablet	8,274.41
Cliff Camp, 1 mile northwest of, north line of, sec. 12, T. 11 S., R. 27 E., in granite ledge on west bank of North Fork of King River, 50 feet north of sheep bridge; tablet	6,177.98

THREE SPRINGS, SOUTH TO RODGERS RIDGE.

T. 12 S., R. 27 E., sec. 1, 5.5 miles southwest of Three Springs, 150 feet south of forks of trail on Rodgers Ridge, about 3.5 miles south of crossing of Rancheria Creek, in rock; bronze tablet	6,844.28

HORSE CORRAL MEADOWS, WEST ALONG TRAIL VIA BIG MEADOW AND GENERAL GRANT PARK, TO MILLWOOD.

	Feet.
Big Meadows, sec. 8, T. 14 S., R. 29 E., 125 feet south of road, between Ellis Camp and Open Meadow, at foot of rock mound; bronze tablet	7,662.74
Log Corral Meadow, sec. 4, T. 14 S., R. 28 E., 300 feet west of forks of General Grant Park and Happy Gap trails, 50 feet south of Happy Gap and Millwood trails, north side of road, in granite rock; bronze tablet	7,229.19

DUNLAP QUADRANGLE.

RODGERS RIDGE, SOUTHWEST TO DUNLAP.

Three Springs, 11.75 miles southwest of, between South and North forks of King River, at point where Rodgers trail from river reaches summit, 10 feet west of trail, in rock; bronze tablet	4,672.98
King River, crossing on Rodgers trail at Flume station No. 3, 130 feet north of river, 100 feet north of trail, in rock; bronze tablet stamped "1030"	1,034.03
Dunlap, 7 miles north of, 4.33 miles south of King River, 2 miles north of Akers (jr.) house, in saddle of ridge, 50 feet west of trail, in granite ledge; bronze tablet	3,566.23
Dunlap, 5 miles north of, summit of divide between Dunlap and White Deer Flat, southwest corner of pasture, 50 feet east of road, inside of fence; bronze tablet	2,399.94
Dunlap, 25 feet east of gate to Mountain Home Hotel, flush with ground, against fence, in rock; bronze tablet	1,915.38

MILLWOOD, WEST TO DUNLAP.

Millwood, opposite junction of flumes at north side of Sanger Lumber Company's shipping yard, in granite ledge in hill; bronze tablet	5,111.93
Dunlap, 2 miles east of, north side of road, at point of hill, in granite ledge 4 feet high; bronze tablet	2,388.98

KINGRIVER POST-OFFICE, EAST TO DUNLAP.

Kingriver post-office, 3 miles east of, at intersection of Millwood and Sanger and Reedly roads, at southwest corner of vineyard; iron post	395.32
Kingriver post-office, 7 miles east of, in front of Clarks Valley church, south side of road, in top of granite ledge; aluminum tablet	470.28
Kingriver post-office, 10 miles east of, 3 miles east of Clarks Valley Church, 1.75 miles west of Street's eating house, 0.25 mile east of small ridge crossing road, granite rock, 4 by 8 by 114 feet, on road right of way; aluminum tablet stamped "587 F" (?)	586.80
Squaw Valley post-office, 100 feet southeast of, in rock; aluminum tablet stamped "1692 F"	1,693.09
Dunlap, 5.4 miles west of, 5.33 miles east of Squaw Valley store, 2 miles west of Mr. Irvin's house, west side of tributary of Mill Creek, 5 feet north of road, in top of granite ledge; aluminum tablet stamped "1501 F"	1,501.84

NEAR LETCHER, NORTHEAST TO HUMPHREYS STATION.

	Feet.
Humphreys, 700 yards north of station, 6 feet west of road, 100 feet west of creek, at small flat, in granite ledge; aluminum tablet stamped "1048 F"	1,044.424

FRESNO QUADRANGLE.

FRESNO, EAST ALONG STAGE ROAD TO KINGRIVER POST-OFFICE.

Fresno, Southern Pacific Railroad passenger station; tablet	289.983
Fresno, 3 miles east of station, 400 feet west of crossing of Sunnyside car line and Ventura avenue, 1 mile east of Fresno schoolhouse, south edge of road; iron post	304.849
Fresno, 6 miles east of, northeast corner of Sunnyside vineyard, north side of Centerville road, west side of Fowler road, at intersection; iron post stamped "323 B"	323.024
Fresno, 9 miles east of, on south edge of Centerville road, 40 feet east of section line, opposite square yellow house; iron post	348.49
Centerville, 4 miles west of, 50 feet west of corner of section, at road crossing, between wheat ranches, south edge of road; iron post	372.77
Centerville (Kingriver post-office), 1 mile west of, 0.25 mile east of Fowler ditch, south edge of county road; iron post	393.35

FRESNO, ALONG SOUTHERN PACIFIC RAILROAD RUNNING EAST, TO LAS PALMAS (MALTERMORO); THENCE NORTH VIA CLOVIS, TO POLLASKY; THENCE ALONG HIGHWAY WEST, TO CLOSURE ON PRECISE LINE AT MADERA.

Barton, 1.2 miles east of, in southeast corner of vineyard, north of schoolhouse, east of wagon road, south of track; iron post	316.556
Tarpy, 150 feet north of station platform, at southwest corner of northwest quarter sec. 20, T. 13 S., R. 21 E., on ditch bank west of track; iron post	347.187
Clovis, at west edge of railroad right of way, 75 feet south of first switch block south of planing mill; iron post	356.084
Gordon, 150 feet north of south end of switch, at west edge of railroad right of way; iron post stamped "391"	391.250
Pollasky, 450 feet south of station, opposite milepost 231, at east edge of right of way of railroad; iron post stamped "337"	337.035
Pollasky, 6.25 miles west of, 75 feet north of corner of small pasture at rocky point, south side of road; iron post stamped "451"	451.155
Cottonwood schoolhouse, 0.5 mile north of, north side of road, against fence of adobe ranch; iron post stamped "342"	342.188
Madera, 4 miles east of, 200 feet east of first small hill south of Sugar Pine and Madera road, 20 feet south of lumber flume, at north side of public road; iron post stamped "304"	304.347

CLOVIS, NORTHEAST ALONG ROAD, TO NEAR LETCHER.

Flume section house No. 7, 50 feet north of, 3 miles northeast of Clovis, east side of road; iron post	409.100
Collins ranch, 1.1 miles east of, southwest of section house No. 6, south side of road, opposite curve in flume; iron post	460.849
Letcher, 0.5 mile north of, in granite rock in pasture, 50 feet east of county road; aluminum tablet stamped "601 F"	597.241

KAISER QUADRANGLE.

HUMPHREYS STATION, NORTH ALONG ROAD VIA TOLLHOUSE AND OCKENDEN, TO SHAVER.

	Feet.
Pine Ridge, sec. 9, T. 10 S., R. 24 E., 100 feet south of store and post-office, in top of granite bowlder 5.5 by 8 feet; aluminum tablet stamped "4942 F"	4,938.332
Shaver, sec. 13, T. 9 S., R. 24 E., 150 feet north of mill and machine shop, in granite ledge; aluminum tablet stamped "5275 F" (on a single spur line)	5,271.531

MUSIC'S OLD MILL (OCKENDEN), OVER COUNTRY ROAD AND TRAIL VIA MARKWOOD AND DINKEY CREEK MEADOWS, TO DIVIDE BETWEEN BEAR AND DEER CREEKS ON KINGS RIVER TRAIL.

T. 10 S., R. 25 E., sec. 12, 2.5 miles east of Markwood Meadows, 400 feet south of road, east of Summit Meadows, in granite ledge; aluminum tablet stamped "6492 F"	6,488.598
Dinkey Meadows, sec. 20, T. 10 S., R. 26 E., 50 feet south of road, 300 feet south of first cabin, about 0.5 mile west of bridge over Dinkey Creek and 300 feet south of south bank, in granite rock; aluminum tablet	5,607.484
Snow Corral, 4.5 miles east of Bear Creek, at point of hill, 50 feet north of trail, on east slope of hill west of meadow, 0.8 mile east of summit of ridge, in granite rock; aluminum tablet stamped "7118 F" (elevation by Tehipite levels from Kaweah 7,119.44)	7,115.758

DINKEYS MEADOWS, NORTH VIA TRAIL, TO MOUTH OF TAMARACK CREEK.

T. 9 S., R. 26 E., sec. 30, 1.7 miles north of Dry Meadows, east of trail, at summit of ridge, in granite ledge at curve; aluminum tablet stamped "7202 F"	7,199.924
T. 8 S., R. 25 E., sec. 35, Tamarack Creek, 150 feet from ford, west of Red Mountain trail, in granite bowlder; aluminum tablet stamped "7141 F"	7,148.935

MOUTH OF TAMARACK CREEK, VIA MONO TRAIL AND MONO CREEK CROSSING, TO 2.3 MILES NORTHEAST OF SOUTH FORK OF SAN JOAQUIN RIVER.

T. 8 S., R. 26 E., sec. 18, Big Creek, 0.6 mile north of crossing, east of north fork of Big Creek, 200 feet east of ford, in granite ledge; aluminum tablet stamped "6876 F"	6,883.669
T. 7 S., R. 26 E., sec. 26, Kaiser Ridge, summit of divide north of Kaiser Pass, east of trail, opposite Luck Point, in granite bowlder; aluminum tablet stamped "9295 F"	9,302.591
T. 7 S., R. 27 E., sec. 7, 100 feet north of South Fork of San Joaquin River, 200 feet west of Mono trail ford, in granite ledge at foot of bluff; aluminum tablet stamped "6405 F"	6,412.356

MONO CREEK, ON MONO TRAIL, NORTHWEST VIA CATTLE TRAIL, TO MILLER'S BRIDGE, OVER MIDDLE FORK OF SAN JOAQUIN RIVER.[a]

T. 6 S., R. 26 E. (unsurveyed), 3.2 miles southeast of Rock Creek, in flat small meadow, 10 feet south of trail, in granite bowlder; bronze tablet stamped "7061 F"	7,068.706

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[a] See under "Mount Lyell quadrangle," p. 118.

	Feet.
Bear Meadow, 0.5 mile northwest of, south of trail, on summit west of Bear Meadow, in granite ledge; bronze tablet stamped "7554 F"	7,561.709
Cassidy Meadow, south side of Rattlesnake Lake, sec. 24, T. 5 S., R. 25 E., east of granite point, in ledge between trail and lake; bronze tablet stamped "5576 F"	5,583.419

TOLLHOUSE SCHOOLHOUSE, NORTHWEST ALONG PUBLIC ROAD, TO POWER HOUSE; THENCE ALONG PIPE LINE, TO RESERVOIR; THENCE ALONG DITCH TO A POINT 2 MILES SOUTHEAST OF NORTH FORK.

T. 10 S., R. 23 E., sec. 8, south of intersection of Pine Ridge and power-house roads, in top of granite ledge; bronze tablet stamped "2013 F"	2,009.411
T. 9 S., R. 23 E., sec. 18, San Joaquin, light and power house, at northeast corner of building, in granite pillar; bronze tablet stamped "1013 F"	1,009.326
T. 8 S., R. 23 E., sec. 30, North Fork, 2 miles southeast of post-office, west of road and ditch, at sharp curve above field and house, in granite bowlder 10 by 8 feet; bronze tablet stamped "2503 F"	2,499.788

LOS BANOS, MERCED, SONORA, AND YOSEMITE QUADRANGLES.

MARIPOSA AND MERCED COUNTIES.

The elevations in this list are based on an aluminum tablet in southeast corner of the county court-house at Merced. The elevation of this is accepted as 171.118 feet above mean sea level as determined by precise leveling from Benicia.

The work was done in 1905 mostly by Mr. C. H. Semper, levelman, partly run as a double-rodded line and partly the mean of lines run in opposite directions. The connection Yosemite Point to Snow Flats was made by Mr. R. A. Farmer, topographer.

MERCED QUADRANGLE.

MERCED, ALONG HIGHWAY, TO MERCED RIVER.

	Feet.
Merced, southeast corner of county court-house; aluminum tablet stamped "171 B"	171.118
Merced, 4.3 miles north of, at entrance to Crocker Huffman back ranch, west side of road, 20 feet north of gate; iron post stamped "175 B"	175.222
Sixmile House, northeast corner of fork with road to east; iron post stamped "206 B"	205.775
Sixmile House, 3.3 miles north of, 65 feet south of bridge over creek, east side of road; iron post stamped "377 B"	376.949
Sixmile House, 6.7 miles north of, at northwest corner of fork with road to west; iron post stamped "284 B"	283.913

AMSTERDAM, SOUTHEAST ALONG RAILROAD, TO MERCED.

Amsterdam, 3.3 miles southeast of, north margin of railroad and highway, 4 feet east of milepost 157; iron post stamped "196 B"	195.984
Amsterdam, 6.4 miles southeast of, at southwest corner of fork with road to Atwater, at J. J. Gray's ranch house; iron post stamped "175 B"	175.333

LOS BANOS QUADRANGLE.

SNELLING, WEST TO HOPETON; THENCE SOUTH TO AMSTERDAM.

	Feet.
Snelling, 4.5 miles southwest of, at corner of fork with road to north, at fence corner of J. G. Ruddle's ranch; iron post stamped "204 B"	204.037
Hopeton, at southeast corner of fork with private road, in front of saloon; iron post stamped "185 B"	184.986
Hopeton, 2.2 miles south of, southwest end of bridge over Merced River, west margin of road; iron post stamped "172 B"	172.245
Amsterdam, 140 feet west of large warehouse, 10 feet east of station signboard, 20 feet north of track; iron post stamped "215 B"	215.156

SONORA QUADRANGE.[a]

MERCED RIVER, NORTHEAST TO SNELLING; THENCE EAST TO MERCED FALLS; THENCE NORTHEAST TO COULTERVILLE; THENCE EAST TO 2.4 MILES SOUTHEAST OF BOWER CAVE.

	Feet.
Snelling, 1.7 miles southwest of, 640 feet north of Merced River roller mills, 60 feet southeast of end of bridge over Merced River, at fence line; iron post stamped "243 B"	243.114
Snelling, at southwest corner of Lewis and Third streets; iron post stamped "259 B"	259.008
Snelling, 2.7 miles east of, on south side of road, on line of east margin of I. J. Buckley's brick ranch house; iron post stamped "291 B"	291.026
Merced Falls, at northeast corner of yard of Merced Falls Power Company, on margin of road; iron post stamped "351 B"	351.125
Merced Falls, 2.9 miles north of, at summit of mountains, 30 feet west of road; iron post stamped "764 B"	763.825
Webbs, at southwest corner of yard fence, margin of road; iron post stamped "1046 B"	1,045.953
Peter Senges, at gate leading to ranch house, at margin of fence; iron post stamped "1128 B"	1,127.958
Peter Senges, 1.5 miles north of, at junction of Piney Creek with Merced River, 125 feet south of creek, 700 feet west of river, near corner of fence; iron post stamped "556 B"	555.979
Baxter post-office, northeast corner of yard fence; iron post stamped "1250 B"	1,249.912
Baxter, 3.1 miles north of, at junction of roads to Coulterville and Horseshoe Bend, 10 feet south of stage station office; iron post stamped "858 B"	857.965
Coulterville, opposite southeast corner of Jeffrey's Hotel, at corner of street in front of burned brick building; iron post stamped "1676 B"	1,676.092
Coulterville, 2.5 miles east of, 0.6 mile east of forks of road, at horseshoe bend in road, south side of fence line, near large oak 4 feet in diameter; iron post stamped "2211 B"	2,211.034
Coulterville, 5.7 miles east of, at summit of mountain, 0.4 mile east of Mountain View saloon, 15 feet south of road; iron post stamped "3346 B"	3,346.039
Bean Creek Bridge, 1.5 miles east of, in front of W. H. Dudley's ranch house, at northwest corner of front yard fence; iron post stamped "2984 B"	2,984.063

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[a] For additional elevations outside this quadrangle see p. 121.

	Feet.
Bower Cave, at road crossing North Fork of Merced River, 50 feet east of river, at north margin of road; iron post stamped "2349 B"	2,349.038
Bower Cave, 2.4 miles southeast of, at northeast corner of schoolhouse yard; iron post stamped "2939 B"	2,939.069

YOSEMITE QUADRANGLE.

NEAR BOWER CAVE, SOUTHEAST TO MERCED RIVER; THENCE EASTERLY ALONG SAME TO YOSEMITE VALLEY.

Kinsley, on south side of road, at margin of fence, directly opposite post-office; iron post stamped "2715 B"	2,714.998
Jenkins Mountain, summit of mountain, on trail, 15 feet south of large oak; iron post stamped "3289 B"	3,289.039
Jenkins Mountain, at east foot of, 145 feet west of Big Grizzly Creek, 130 feet north of Merced River, 30 feet east of old cabin, at edge of trail; aluminum tablet [a] stamped "1324 B"	1,323.761
Ned Gulch, 1.9 miles east of, 0.5 mile east of junction of South Fork with river, on long flat ground, at foot of slope, north side of large rock; aluminum tablet stamped "1425 B"	1,424.982
Furgeson Mine, 2.2 miles east of, 2 feet south of bridge over Merced River, west abutment, 20 feet east of west end; aluminum tablet stamped "1586 B"	1,585.908
Merced River Bridge, 2.5 miles east of, at west foot of steep grade, in open ground covered with bowlders, 35 feet east of trail, large granite rock, in river face; aluminum tablet stamped "1824 B"	1,823.966
Crane Creek, 0.8 mile east of, trail nearly level with river, 95 feet west of common corner of secs. 9, 10, 15, and 16, T. 3 S., R. 20 E., 10 feet east of large crooked oak, perpendicular rock; aluminum tablet stamped "2117 B"	2,116.969
Crane Creek, 2.4 miles east of, 260 feet north of zig zag in trail close to river; in face of perpendicular rock; aluminum tablet stamped "2738 B"	2,738.001
Cascade House, 0.7 mile south of, on main road, 100 feet southwest of junction of road with river trail, in face of perpendicular rock; aluminum tablet stamped "3511 B"	3,510.981
Yosemite, 50 feet west of west boundary stake of old State park, on north side of road to Cascade Falls, large granite bowlder; aluminum tablet stamped "3576 B"	3,576.004
Yosemite Valley, north side of river, at west turn to bridge near margin of road, 75 feet northwest of Pohone Bridge, large bowlder; aluminum tablet stamped "3880 B"	3,879.767
Yosemite Valley, directly opposite Guardian's office, at east margin of road, top of large granite rock; aluminum tablet stamped "3964 B"	3,964.287
Yosemite Valley, at junction of roads, north side of river, north and east side of roads, 150 feet northeast of iron bridge over Merced River, at Sentinel Hotel, in center of top of concrete pier 2.5 feet high, base 20 by 20 inches, and top 12 by 12 inches; aluminum plug stamped with a triangle, and "U. S. G. S."	3,960.096

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[a] From this point the old system of double rod was used.

	Feet.
Immediately over above bench mark is a rectangular aluminum plate half inch thick marked "Charles D. Walcott, Director, U. S. Geological Survey, Latitude 37° 44′ 40″, Longitude 119° 35′ 21″	3,960.138
Yosemite Valley, at power house, 40 feet south of trail to Vernal Falls, 40 feet north of power house bridge, 30 feet north of road, large granite bowlder; aluminum tablet stamped "4034 B"	4,034.061

UP YOSEMITE FALLS TRAIL, NORTHEAST TO SNOW FLAT.

Yosemite Valley, at foot of trail to Yosemite Falls, 100 feet west of road, 30 feet south of trail, face of large granite bowlder; aluminum tablet stamped "3989 B"	3,989.013
Yosemite Valley, south of trail to Yosemite Falls, in rock; aluminum tablet stamped "F 1905 5031"	5,030.576
Yosemite Valley, in angle of trail to Yosemite Falls, 100 feet from large flat rock used as lookout to bottom of falls, top of large granite rock; aluminum tablet stamped "5143 B"	5,142.666
Yosemite Valley, top of Yosemite Falls, east side of bridge over Yosemite Creek, south side of rock foundation of abutment; aluminum tablet stamped "6603 B"	6,603.056
Yosemite Point, at west end of iron railing; triangulation tablet	6,934.616
Summit north of trail, rock 5 feet base, 3 feet high; aluminum tablet stamped "F 7852 1905"	7,851.765
Junction of trail with Tioga wagon road, south of, on rock 3 by 3 by 3 feet; aluminum tablet stamped "7981 F"	7,981.013

BRIDGEPORT AND MOUNT LYELL QUADRANGLES.

MONO AND TUOLUMNE COUNTIES.

The elevations in the following list are determined mostly by single unadjusted lines based upon a new elevation at Snow Flats which was determined in 1905 by a single spur from a double-run spur line run to Yosemite Valley from a bench mark at Merced on the precise-level line from Benicia.

The results were formerly published in the Appendix to the Twentieth Annual Report, based upon a double-rodded line from Stockton; but as now corrected the elevations by this list are 4.389 feet greater than by the corrected line from Stockton and 6.355 lower than by single line of 1905 from Laws. Part of a circuit to Mono Mills is on Benton quadrangle (p. 101).

The leveling was done in 1898 under Mr. R. B. Marshall, topographer, by Mr. C. R. Smith, levelman. The bench mark at Miller Bridge was established by L. D. Ryus, levelman, in 1901, from Fresno.

BRIDGEPORT QUADRANGLE.

TO HARDY STATION FROM BENCH MARK 2.5 MILES WEST.

	Feet.
Hardy station, about 2.5 miles west of, on rock ledge 1,400 feet east of bridge over West Walker River, in a bend of the road, on south side of grade; copper bolt stamped "6703" (elevation by corrected line from Stockton, 6,702.518)	6,706.907

	Feet.
Hardy station, at junction of Sonora-Mono toll road and the Carson road, 60 feet east of Little Walker River; iron post stamped "6942"	6,945.830

HARDY STATION, SOUTH ALONG MAIN ROAD, TO BRIDGEPORT; THENCE SOUTHEAST TO BOWIE; THENCE SOUTHWEST TO MONO LAKE.

Summit between Hardy and Bridgeport, 15 feet east of road; iron post stamped "7540 O"	7,544.812
Hunttoon station, on right side of road, 100 feet below water trough; iron post stamped "6837 O"	6,841.999
Bridgeport, 3 miles northwest of, east side of road, at north side of Simmon's Lane; iron post stamped "6496 O"	6,500.556
Bridgeport, at southwest angle of court-house; iron post stamped "6465 O"	6,469.436
Tollgate, Bridgeport, and Bodie road, near northeast corner of gate; iron post stamped "6643 O"	6,647.946
Clearwater Creek crossing, 20 feet north of bridge; iron post stamped "7196 O"	7,201.323
Sheep camp, across road from water trough and 50 feet above; iron post stamped "7350 O"	7,354.824
Hectors station, on Bodie and Lundy road, across road from the dwelling house at edge of orchard and garden; iron post stamped "6760 O"	6,765.322
Jordan Creek crossing of Bodie and Lundy road, 150 feet south of bridge, on north side of road; iron post stamped "6779 O"	6,783.407
T. 2 N., R. 26 E., Diablo meridian, 4 feet east of southwest corner of sec. 19, witnessed by mound of rocks, about midway between Mono post-office and Mono schoolhouse, on hillside, about 350 feet in elevation above lake and about 2,000 feet in horizontal distance from lake shore; iron post stamped "6761 O"	6,765.714
Mono Lake; surface of water, July 27, 1898	6,417.3

MOUNT LYELL QUADRANGLE.

MONO LAKE POST-OFFICE, SOUTHEAST TO RUSH CREEK.

Ney's ranch, sec. 4, T. 1 N., R. 26 E., near Mono Lake shore, in large bowlder on north side of road and 200 feet east of blacksmith shop; aluminum tablet stamped "6423 O"	6,427.471
T. 1 N., R. 26 E., sec. 13, Rush Creek crossing, junction of lake road with Rush Creek road from Farrington station; iron post stamped "6442 O"	6,446.571

NEY'S RANCH (SHORE OF LAKE MONO), SOUTH ALONG ROAD, TO JUNCTION OF ROAD IN SEC. 9, T. 2 S., R. 27 E.

T. 1 N., R. 26 E., northeast corner, sec. 33, Farrington station, 50 feet south of dwelling, inside of fence at edge of road to Walter Lake; iron post stamped "6854 O"	6,858.729
T. 1 S., R. 27 E., sec. 29, Owens River road, 7 miles southeast of Farrington station, at head of short, steep grade, at upper edge of grove of trees, 10 feet left of road; iron post stamped "7601 O" (elevation brought from Mohave, 7,612.182)	7,605.827
T. 2 S., R. 27 E., sec. 9, Long Valley and Owens River road, at junction of with Bodie and Benton wagon road, on north side of road; iron post stamped "7938 O" (elevation brought from Mohave, 7,948.998)	7,942.643

FARRINGTON, SOUTH TO SILVER LAKE.

	Feet.
Grant Lake, at outlet of, 10 feet east of road; iron post stamped "7068 O"	7,073.228
Silver Lake, at outlet of; iron post stamped "7217 O"	7,221.937

NEY'S RANCH, UP LEEVINING CREEK ROAD, TO SEC. 23, T. 1 N., R. 26 E.

	Feet.
T. 1 N., R. 26 E., quarter corner between secs. 23 and 24; iron post stamped "7467 O"	7,472.097

FARRINGTON STATION, SOUTHWEST ALONG ROAD AND TRAIL, TO MONO PASS; THENCE WEST ALONG TRAIL, TO SNOW FLAT.

	Feet.
Walker Lake, 100 feet north of outlet of, at upper end of wagon road where Bloody Canyon trail begins, near dwelling of A. Grose, 100 feet from lake and 123 feet from fence; iron post stamped "7929 O"	7,934.030
Walker Lake; surface of water, September 1, 1898	7,931.6
Sardine Lake; surface of water, September 26, 1898	9,881.1
Mono Pass, 30 feet north from Shore of Summit Lake and 4 feet to right of trail; iron post stamped "10599 O"	10,603.604
Dana Fork, trail at point where sheep trail branches to right through timber alongside hill and where stream turns westward to main trail, continuing northwest down to meadows, in rock at southwest corner of cabin; aluminum plug stamped "U. S. G. S. 9738 Ft. B. M. O."	9,742.563
Soda Springs, 3.5 miles east of, on north side of Tioga road where trail comes in from the meadows to the eastward of road, in outcropping ledge of rock; aluminum bolt stamped "U. S. G. S. 9270 Ft. B. M. O."	9,274.794
Soda Springs, 100 feet west of, in large granite bowlder on south side of trail; aluminum bolt stamped "U. S. G. S. 8594 Ft. B. M. O."	8,598.681
T. 1 S., R. 23 E., southeast corner sec. 1, Diablo meridian; iron post stamped "8555 O"	8,560.118
Cathedral Creek, in conspicuous rock in north side of creek bed, 50 feet from road; aluminum bolt stamped "U. S. G. S. 8337 Ft. B. M. O."	8,342.076
Lake Tanaya, on west shore of, in large bowlder between road and lake shore, about 300 feet east of three log cabins in grove of trees; aluminum tablet stamped "U. S. G. S. 8146 Ft. B. M. O."	8,150.447
Lake Tanaya; surface of water, September 17, 1898	8,146.
Snow Flat, 300 feet southwest of wooden culvert in road crossing, in large granite bowlder, on west side of road; aluminum tablet stamped "U. S. G. S. 8705 Ft. B. M. O." (recovered in 1905 by leveling from Merced, and correction made)	8,710.341

DANA FORK, TRAIL NORTH TO TIOGA.

	Feet.
Tioga Pass summit, on rock on east side of road; aluminum tablet stamped "9941 Ft. B. M. O."	9,946.188
Tioga mine, in ledge of rock, at southwest corner of assay office; round iron plug set in cement and marked "9795"	9,799.745

AT MILLER BRIDGE.[a]

	Feet.
Miller Bridge, sec. 11, T. 5 S., R. 25 E., 15 feet east of briuge over Middle Fork of San Joaquin River, in granite ledge; bronze tablet stamped "4556 F"	4,563.252

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[a] Determined by single unadjusted line by L. D. Ryus in 1901 from Fresno.

BIG TREES, DARDANELLES, JACKSON, OAKDALE, SONORA, AND STOCKTON QUADRANGLES.

CALAVERAS, MONO, SAN JOAQUIN, STANISLAUS, AND TUOLUMNE COUNTIES.

The elevations in the following list are the unadjusted results of a double-rodded primary-level line previously reported upon in Appendix to the Eighteenth Annual Report, corrected in agreement with the elevation at Stockton determined by precise leveling from Benicia, being 0.492 foot greater than values previously published.

The leveling was done in 1896 by Mr. J. B. Lippincott, levelman.

This line closes 4.389 feet low upon the elevation at Hardy station, on Bridgeport quadrangle corrected in agreement with 1905 leveling from Merced.

STOCKTON QUADRANGLE.

AT STOCKTON.

	Feet.
Stockton, southwest corner of Scott avenue (south side of Mormon channel) and Center street, on north iron doorsill, west end of Cool Corner saloon; "Cool Corner" bench mark	15.633
Stockton, southwest corner of Scott avenue and Center street, 18 feet from curb corner and 12 feet north of iron doorsill; iron post stamped "16"	15.973
Stockton channel, at southeast head of, corner of Weber avenue and Eldorado street, east of steps at corner post; iron plate	12.714
Stockton, on the top of a stone post on the north side of the court-house and west side of walk	16.1
Stockton, San Joaquin court-house, in angle of wall at north entrance, west of the door and near columns, between north door and first window west of it; bronze tablet stamped "18"	17.953
Stockton, Southern Pacific passenger station, Milton and Oakland branch; top of rail	18.7

STOCKTON, NORTHEAST ALONG MILTON ROAD AND SOUTHERN PACIFIC RAILROAD, TO PETERS.

J. B. Marsh's house, at northeast corner of entrance of lean-to; iron post stamped "34"	33.605
Farmington, junction with road to, near Smyth's ranch; iron post stamped "67"	66.551
Peters-Linden road, at southeast corner of junction with; iron post stamped "102"	101.825

JACKSON QUADRANGLE.

PETERS, NORTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO MILTON.

Waverly, at crossing of the Stockton-Milton road over Southern Pacific tracks, on south side of track and east side of the crossing sign; iron post stamped "219"	218.285
Waverly, in front of station; top of rail	215.2
Milton, 9 feet north of southeast corner of Peterson & Drake's warehouse and 57 feet south of the railroad track, 60 feet west of the Southern Pacific passenger station; iron post stamped "383"	382.330

MILTON, EAST TO SALT SPRINGS RESERVOIR.

Salt Springs Reservoir, south side of, in large rock about 600 feet south of and in line with dam; copper bolt stamped "1092"	1,091.510

OAKDALE QUADRANGLE.

SALT SPRINGS, SOUTHEAST VIA COPPEROPOLIS, TO MOUNT DIABLO BASE LINE.

	Feet.
Copperopolis, about 2.5 miles north of, east side of road, at a summit between Salt Spring Valley and Copperopolis, at an oblique corner of fence; iron post stamped "1108"	1,107.371
Copperopolis, in front brick wall of Fontana's store, approximately 2 feet above the store floor and 3 feet above stone foundation, opposite Vendome Hotel; bronze tablet stamped "971"	970.759
O'Byrnes Ferry, Stanislaus River, in the stone front wall of Pardee's store, between south window and southeast corner of store, 500 feet north of bridge on west side of Milton-Jamestown road; bronze tablet stamped "432"	431.758
O'Byrnes Ferry, 3 miles east of, at the top of and on the north side of grade, about 3 miles west of the Goodwin ranch; iron post stamped "1090"	1,089.981

SONORA QUADRANGLE.[a]

MOUNT DIABLO BASE, NORTHEAST VIA SONORA, TO NEAR SOULSBYVILLE.

	Feet.
Goodwin's ranch, 1 mile east of house, on north side of road and 6 miles west of Jamestown; iron post stamped "1389"	1,389.045
Goodwin's wine cellar, on north step of, about 6 miles west of Jamestown and 3.5 miles north of Chinese camp; copper plug stamped "1176"	1,175.791
Jamestown, in front wall in the east end of the brick building with iron doors and a stone pavement, on the south side of the road, one-half block west of Sisson's Hotel; bronze tablet stamped "1403"	1,402.424
Sonora, in south post of east entrance in street wall of the courthouse; bronze tablet stamped "1825"	1,824.375
Sonora, in the outside wall 1 foot south of gate at the east edge of the court of Victoria Hotel, facing Washington street; copper bolt stamped "1794"	1,793.648
Soulsbyville, junction with road to, about 3 miles east of Sonora on the north side of Soulsbyville road, near the fence at the Cherokee ranch; iron post stamped "2144"	2,143.381

BIG TREES QUADRANGLE.

NEAR SOULSBYVILLE, NORTHEAST ALONG ROAD, TO PARSONS; THENCE NORTHEAST 2.5 MILES.

	Feet.
Columbia road, in triangle formed by junction with; iron post stamped "3254"	3,253.352
Sugarpine, about 800 feet east of post-office, on rock 12 by 6 feet, 4 feet high, in corral; copper bolt stamped "4468"	4,467.747
Sugarpine, about 2.5 miles east of, in forks of road to Hale's sawmill; iron post stamped "4916"	4,916.099
Genesee place (Saints' Rest), in rock 3.5 by 2.5 feet, 1.5 feet high, 10 feet east of barn, 10 feet south of road, 150 feet north of creek and on west edge of a group of trees; copper bolt stamped "5139"	5,138.461
Ball Mountain summit, between North Fork of Tuolumne and South Fork of Stanislaus rivers, on north side of road, about 6 miles west of Strawberry, at the northeast head of draw, on large bowlder; bronze tablet stamped "5624"	5,623.563

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[a] For additional elevations on this quadrangle see p. 115.

	Feet.
Cold Spring, about 0.75 mile west of, at the summit between North Fork of the Tuolumne and South Fork of Stanislaus rivers, at bend of road; iron post stamped "5697"	5,696.568
Parsons (Strawberry), 48.8 feet southeast from southeast corner of Parson's store and 24.8 feet from southwest corner of Parson's house, on east side of road on north side of South Fork of Stanislaus River; iron post stamped "5240"	5,239.435
Strawberry, about 2.5 miles east of, in top of granite bowlder at the summit between South Fork and Main Fork of Stanislaus River, and 50 feet east of road, trees blazed in vicinity; copper bolt stamped "6134"	6,133.894

DARDANELLES QUADRANGLE.

POINT 2.5 MILES NORTHEAST OF PARSONS, NORTHEAST TO EUREKA VALLEY.

Cow Creek, 50 feet east of crossing of, in side of large bowlder on south of road; bronze tablet stamped "5769"	5,769.121
T. 5 N., R. 18 E., 2 feet north of southeast corner sec. 15, north of road between mileposts 30 and 31, 6 feet from sugar pine tree marked "B. T. 60° E. 5 feet"; iron post stamped "5943"	5,942.822
Mill Creek, 200 feet east of crossing, on north side of road, trees blazed in vicinity; iron post stamped "6273"	6,272.380
Niagara Creek, 150 feet north of crossing, in large granite bowlder, the highest one of the group, trees blazed in vicinity; copper bolt stamped "6530"	6,529.408
T. 6 N., R. 19 E., sec. 31, summit between Niagara Creek and Stanislaus River, at the head of grade and about 2,000 feet north of the Niagara Creek crossing, in a granite rock on north side of road, 4 feet above road level, on southwest face of rock; bronze tablet stamped "6638"	6,637.268
T. 6 N., R. 19 E., sec. 23, about 2 miles southwest from Brightmans Flat, on south side of road, in pyramid-shaped rock 6 feet high, at level road below Pattersons grade; bronze tablet stamped "5664"	5,664.204
Stanislaus River, in granite ledge 28 feet northwest from the northwest corner of bridge, and approximately 2 miles west from Douglas ranch and 6 feet above road level; copper plug stamped "5828"	5,827.953
Eureka Valley, 6 feet south of southwest corner of Douglas ranch; iron post stamped "6076"	6,075.838

EUREKA VALLEY, EAST VIA SONORA PASS, TO NEAR HARDY STATION.

Bakers station, about 0.25 mile southeast of, on rock bench at the foot of and west side of grade, 180 feet east of road and 93 feet south of blazed yellow pine; bronze tablet stamped "6265"	6,265.105
Sonora Pass, 3 miles west of, on a rock ledge on west of road and 1,000 feet west of second crossing of the creek, trees blazed in vicinity; copper bolt stamped "8398"	8,398.147
Sonora Pass, at summit of, on south side of road; iron post stamped "9623"	9,623.427
Sonora Pass, 3.5 miles east of summit of, at mule corral, just west of a large canyon on south, and south of road; iron post stamped "8583"	8,583.206
Crinoline grade, foot of, on top of bowlder 9 feet high and 10 feet in diameter, on south side of road, 10 miles west of Hardy station and 1,360 feet west of Leavitt's chimney, between the road and fence; copper bolt stamped "7152"	7,151.467

BYRON, CONCORD, MOUNT DIABLO, NEW ALMADEN, PALO ALTO, PLEASANTON, SAN FRANCISCO, SAN JOSE, SANTA CRUZ, STOCKTON, AND TESLA QUADRANGLES.

ALAMEDA, CONTRA COSTA, SAN JOAQUIN, SAN MATEO, SANTA CLARA, AND SANTA CRUZ COUNTIES.

The elevations in the following list are based upon mean sea level computed from tidal records at Martinez, Pacheco, Black Diamond, and Redwood, and further controlled at Lathrop by precise leveling from Benicia.

The leveling on San Francisco, Concord, Mount Diablo, Byron, and part of Pleasanton quadrangles was done in 1896 under Mr. L. C. Fletcher by Mr. J. A. Vogleson, levelman. Most of the work on Pleasanton and some on Stockton, Tesla, and San Jose quadrangles was done in 1903 by Mr. S. E. Blout, levelman. Most of the work on Tesla and part on Stockton quadrangles was done in 1905 under Mr. R. B. Marshall by Mr. C. H. Semper, levelman, and the work on Santa Cruz, Palo Alto, and part of San Jose quadrangles was done in 1899 under Messrs. E. C. Barnard and A. B. Searle, topographers, by Mr. C. C. Ward, levelman.

SAN FRANCISCO QUADRANGLE.

OAKLAND POINT TO OAKLAND, THENCE NORTH ALONG SOUTHERN PACIFIC RAILROAD TO SOBRANTE.

	Feet.
Oakland Point, 30.5 feet from corner of machine shop, 19 feet from corner of office of Southern Pacific Company, 1 foot from west edge of walk from railroad track to machine shops and 9 feet south from west side of doorway, 0.4 foot underground; Southern Pacific Company's bench mark on top of a 30-foot bar of railroad iron driven in solid ground by means of a pile driver (afterwards covered by a wooden platform with a hole bored through the planking so as to make it easy of access)	8.151
Oakland, Broadway front of Hall of Records, in foundation on north side of entrance, 4 feet above ground; bronze tablet stamped "24"	24.343

CONCORD QUADRANGLE.

MARTINEZ, SOUTHEAST ALONG HIGHWAY, NEAR PACHECO, TO CONCORD.

	Feet.
Pacheco, brick building, formerly a warehouse with iron shutters, owned by G. Anderson, third building north of road to Concord and post-office; iron piece projecting from wall, U. S. C. & G. S. B. M	21.210
Pacheco, 0.75 foot south of preceding bench mark, in wall of same building; bronze tablet stamped "21"	21.197
Concord railroad station; top of rail at road crossing	42.0
Concord, west corner of public square, southeast intersection of Main street with street running by Kline's Hotel; iron post stamped "65"	64.610

DANVILLE, NORTH ALONG ROAD, TO PACHECO.

	Feet.
Alamo, east side of Main street, north side of lane to railroad ranch, opposite hotel and post-office; iron post stamped "270"	270.327
Walnut Creek, in schoolhouse yard, between eucalyptus trees, near east fence; iron post stamped "151"	150.750

MOUNT DIABLO QUADRANGLE.

ANTIOCH, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO NEROLY SIDING.

	Feet.
Neroly siding, county road just north of, gate to private road crossing, first panel east of gate: iron post stamped "79"	78.923

NEAR BRENTWOOD, WEST UP MARSH CREEK, TO MORGAN TERRITORY; THENCE NORTHWEST VIA CLAYTON TO CONCORD.

Morgan Territory, in schoolhouse yard, 55 feet east of northeast corner of schoolhouse; iron post stamped "766"	765.805
Marsh Creek and Mount Diablo Creek, divide between, just east of gate; iron post stamped "955"	955.069
Clayton, intersection of Nortonville and Marsh Creek roads with Main street, near guidepost; iron post stamped "395"	395.105

FROM BOUNDARY OF CONTRA COSTA AND ALAMEDA COUNTIES NORTHWEST TO DANVILLE.

Danville; railroad track south of station	370.5
Danville, in brick foundation of schoolhouse; bronze tablet stamped "365"	364.495

BYRON QUADRANGLE.

NEROLY, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO BRENTWOOD; THENCE SOUTH ALONG ROAD, TO LIVERMORE.

Brentwood, west of track at north end of platform, across tracks from store; iron post stamped "77"	76.890
Vascoe schoolhouse, opposite, on west side of road; iron post stamped "401"	401.377
Vascoe divide, east side of road; iron post stamped "970"	969.767

STOCKTON QUADRANGLE.[a]

LATHROP, SOUTHWESTERLY ALONG SOUTHERN PACIFIC RAILROAD, TO MIDWAY.

Lathrop, 3.5 miles southwest of, 30 feet southwest of milepost 79, south side of track; iron post stamped "17.638 B"	17.576
Milepost 75, 10 feet north of, south side of track; iron post stamped "22.181 B"	22.119
Banta station, in front of freight house; top of rail	26.8
Milepost 72, 18 feet north of, iron post stamped "53.927 B"	53.865
Ellis, 1 mile west of, 4 feet north of milepost 69; iron post stamped "102.656 B"	102.594

ELLIS, SOUTH TO DAY'S FARM.

Ellis, 4.8 miles south of, 1.500 feet west of, at northwest angle of road to Ellis; iron post stamped "265 B"	264.068

TESLA QUADRANGLE.

MIDWAY, WESTERLY ALONG SOUTHERN PACIFIC RAILROAD, TO LIVERMORE.

Midway station, 5 feet east of milepost 64; iron post stamped "351.341 B"	351.280
Milepost 60, 300 feet west of, south side of track, at road crossing; iron post stamped "539.602 B"	539.540
Altamont, 5 feet west of milepost 56; iron post stamped "739.899 B,"	739.837
Milepost 52, 5 feet north of; iron post stamped "575.749 B"	575.687

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[a] Additional elevations on Stockton quadrangle are given on precise line (p. 15) and on primary line east of Stockton (p. 120).

LIVERMORE, EASTERLY VIA SOUTHERN PACIFIC RAILROAD, TO 5 MILES EAST OF CARNEGIE; THENCE ALONG HIGHWAYS, TO DAY'S FARM.

	Feet.
T. 3 S., R. 2 E., northwest corner of sec. 23, at junction of Tesla and Mocho roads, east angle; iron post stamped "601. B"	601.117
T. 3 S., R. 2 E., north side of sec. 24, south of road, nearly opposite large farm gate; iron post stamped "688 B"	688.046
T. 3 S., R. 3 E., near center sec. 20, 6.5 miles west of Tesla; 0.25 mile west of Al Allen's house, south of road, near fence; iron post stamped "B 832"	831.765
T. 3 S., R. 3 E., sec 27, 3.5 miles west of Tesla, half way between Old Richards mine and house, north of road; iron post stamped "B 1319"	1,319.400
Tesla, 25 feet east of entrance to Tesla Hotel; iron post stamped "No. 11, 886 B"	885.053
Tesla, in brick steps of Tesla Hotel; aluminum tablet stamped "882 B"	881.242
T. 3 S., R. 4 E., south side of sec. 29, 2.9 miles east of Tesla, near San Joaquin and Alameda County line, 20 feet south of track, 200 feet east of railroad culvert; iron post stamped "700 B"	699.236
T. 3 S., R. 4 E., sec 35, 1.1 miles east of Carnegie, 20 feet south of track, 5 feet north of road, opposite two old shanties; iron post stamped "540 B"	539.137

LIVERMORE, SOUTHEAST VIA ARROYO MOCHO, TO CORNER TS. 4 AND 5 S., R. 4 E.; THENCE ALONG TRACY TRAIL, TO 1.1 MILES EAST OF CARNEGIE.

	Feet.
T. 3 S., R. 2 E., south side of sec. 36, 6.2 miles east of Livermore, near fence corner, at 48-inch oak tree, north of road; iron post stamped "784 B"	783.890
T. 4 S., R. 3 E., northeast quarter of sec. 8, Mud Springs, 50 feet south of water trough, west side of road, at fence; iron post stamped "1412 B"	1,412.136
T. 4 S., R. 3 E., east side of sec. 13, 5.4 miles southeast of Mud Springs, at Fox ranch, at gate across county road, 5 feet west of road at township line; iron post stamped "2428 B 2 S"	2,427.978
T. 5 S., R. 4 E., north side, sec. 5, 600 feet south of Jones house, 20 feet west of road; iron post stamped "2415 B"	2,415.181
T. 4 S., R. 4 E., south side of sec. 10, 3.8 miles north of Corral Hollow Creek, on Hog Back at very rocky point, 6 feet east of trail; iron post stamped "2233 B"	2,233.149

PLEASANTON QUADRANGLE.

LIVERMORE, WEST ALONG ROAD, TO DUBLIN; THENCE NORTHWEST TO CONTRA COSTA-ALAMEDA COUNTY LINE.

	Feet.
Livermore, in front of station; top of rail, main track	482.
Tassajero, junction with road to, at northwest corner; iron post stamped "346"	345.877
Tassajero Valley, about 2.5 miles north of main road, on west side of Tassajero road and 2.2 feet east of monument on county line between Contra Costa and Alameda counties; iron post stamped "485" (on a spur from preceding bench mark)	485.060
Dublin, intersection of center line of San Ramon road and south line of main road; iron post stamped "367"	366.617
Contra Costa and Alameda counties, boundary line, 2.3 feet west of county-line monument, on east side of road; iron post stamped "425"	424.770

LIVERMORE, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO PLEASANTON; THENCE SOUTH TO SUNOL; THENCE WEST TO NILES; THENCE SOUTH TO IRVINGTON.

	Feet.
Livermore, 300 feet east of station, near eucalyptus tree 18 inches in diameter; iron post stamped "486 B"	486.153
Livermore, Farmers' Union Building, southeast corner of block north of Southern Pacific track; bronze tablet stamped "488"	487.496
Milepost 45, 225 feet west of, north side of track; iron post stamped "381.911 B"	381.873
Pleasanton, 4 feet east of milepost 42; iron post stamped "360.736 B"	360.723
Milepost 39, 5 feet north of; iron post stamped "297.496 B"	297.507
Milepost 36, 150 feet west of, on south side of track near fence; iron post stamped "227 B"	227.157
Farwell station, 200 feet east of; iron post stamped "167.099 B"	167.158
Niles, in school yard, 6 feet north of west gate; iron post stamped "76.408 B"	76.491
Irvington, 100 feet east of Irvington Hotel, at northeast corner of fence; iron post stamped "71.631 B"	71.743

IRVINGTON, NORTHEAST ALONG ROAD TO LIVERMORE.

Mission Pass, 5 feet east of electric-light pole No. 3803; iron post stamped "649.890 B"	649.923
Sunol, 2 miles east of, 40 feet from bridge, north side of road; iron post stamped "336.986 B"	336.940
Livermore, 5 miles southwest of, opposite old barn on east side of road, 10 feet west of oak on north side of road; iron post stamped "609.917 B"	609.791

SAN JOSE QUADRANGLE.

IRVINGTON, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO SAN JOSE.

Milepost 37; iron post stamped "46.563 B"	46.703
Milepost 40, 350 feet south of, opposite small bridge, east side of track; iron post stamped "11.301 B"	11.465
Milepost 43, 475 feet south of, at highway crossing, on west side of track; iron post stamped "37.505 B"	37.694
Milepost 46, 50 feet east of, east side of track; iron post stamped "69.117 B"	69.330

AT SAN JOSE.

San Jose, 150 feet east of Southern Pacific Company's standard-gage station; log bolt in circular base of iron water stand about 2 feet in diameter[a]	91.76
San Jose, at southwest corner of St. James and First streets, opposite St. James square, set horizontally in west end of lower edge of stone banister on north side of entrance to Santa Clara County Hall of Records; aluminum tablet stamped "98 S F"	98.317

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[a] This is a bench mark of the United States Coast and Geodetic Survey, but the elevation (given as 90.555 feet) was not accepted, as Mr. Ward's levels brought from Redwood are in a closed circuit.

NEW ALMADEN QUADRANGLE.

SAN JOSE, SOUTHWEST ALONG NARROW-GAGE RAILROAD, TO LOS GATOS.

	Feet.
Los Gatos, opposite station, in west corner of yard around Hotel Lindon on Santa Cruz avenue; iron post stamped "412 S F"	412.012

SANTA CRUZ 30′ QUADRANGLE.

LOS GATOS, SOUTHWEST ALONG ROAD, TO BOULDER CREEK.

Montezuma schoolhouse, 45 feet north of, in corner of yard; iron post stamped "1459 S F"	1,459.074
T. 9 S., R. 2 W., at center of northeast quarter of sec. 12, 30 feet south of Brown schoolhouse; iron post stamped "2135 S F"	2,135.031
Bear Creek schoolhouse, 10 feet north of northwest corner of; iron post stamped "735 S F"	735.042
Boulder Creek, at east side of fountain in "Boulder Creek House" yard; iron post stamped "484 S F"	484.009

BOULDER CREEK, NORTHWEST ALONG WAGON ROAD AND TRAIL, TO IVERSON'S RANCH.

Sequoia schoolhouse, in yard at south side of stile; iron post stamped "916 S F"	916.025
Butano Ridge, at end of wagon road; iron post stamped "2319 S F"	2,318.980
Iverson's ranch, at junction of Boulder Creek and Pescadero Creek trail with road to La Honda, west side of road; iron post stamped "422 S F"	421.999

LA HONDA, NORTH TO DIVIDE BETWEEN ARROYA HONDA AND SANTA CLARA VALLEYS.

La Honda, north side of front entrance to hotel at steps; iron post stamped "403 S F"	403.021
Summit of divide, between Arroya Honda and Santa Clara valleys, in forks of road at northwest corner of saloon; iron post stamped "1680 S F"	1,679.450

BROWN SCHOOLHOUSE, NORTH ALONG ROAD, TO SEC. 36, T. 8 S., R. 2 W.

T. 8 S., R. 2 W., sec. 36, at junction of road leading north with reservoir road, near county line, in Mrs. Gist's yard, at north side of gate; iron post stamped "2256 S F"	2,255.959

BOULDER CREEK, SOUTH ALONG ROAD, TO SANTA CRUZ.

Ben Lomond, 10 feet from northwest corner of office of Rowardennen Hotel, in yard; iron post stamped "344 S F"	344.012
Felton schoolhouse, midway between two front entrances; iron post stamped "286 S F"	285.954
Santa Cruz, in left base of arch at entrance to court-house; aluminum tablet stamped "18 S F"	18.017

PALO ALTO 15′ (SANTA CRUZ 30′) QUADRANGLE.

IVERSON'S RANCH, WEST ALONG PIPE LINE, TO TAR CREEK.

T. 8 S., R. 4 W., east side of sec. 1, 0.2 mile west of Tar Creek, at right of pipe-line trail, in heavy timber; iron post stamped "420 S F"	420.035

IVERSON'S RANCH, NORTH TO ALPINE HOUSE; THENCE WEST TO LA HONDA.

	Feet.
Alpine schoolhouse, 0.25 mile west of, in triangle between roads at junction of Mayfield and La Honda road with Page Mill road; iron post stamped "1590 S F"	1,590.009

SANTA CLARA-ARROYA HONDA DIVIDE, NORTHEAST TO PALO ALTO.

Portola, junction with road to, at corner of fence surrounding E. K. Preston's house, on south side of road; iron post stamped "388 S F"	388.010
Leland Stanford Junior University, on south side of inner quadrangle, set next to wall on south side of west building, on top of stone ledge on west side of cellar steps; aluminum tablet stamped "89 S F"	88.577

REDWOOD, SOUTHEAST ALONG COUNTY ROAD, TO SAN JOSE.

Redwood, at northeast corner of Sixth and Arguello streets, opposite Southern Pacific Company's station, top of fire hydrant (C. & G. S. bench mark given as 15.412 feet above mean lower low water)	12.312
Palo Alto, at northeast corner of station, on iron rail surrounding walk, which rail is set in brick and cement (established by the Coast and Geodetic Survey and the elevation given as 63.327)	63.360

CARQUINEZ, GEYSERVILLE, GUERNEVILLE, NAPA, SANTA ROSA, AND TAMALPAIS QUADRANGLES.

MARIN, NAPA, SOLANO, AND SONOMA COUNTIES.

The elevations in the following list are based mostly on a bench mark of the Coast and Geodetic Survey at Benicia Arsenal, the upper surface of a $\frac{5}{8}$-inch iron bolt driven in a hole drilled horizontally in the southwest face of a sandstone rock at top of ledge near high-water mark at Army Point just south of railroad and east of wharf. The elevation of this is accepted as 5.980 feet above mean sea level. For additional elevations on Carquinez and Napa quadrangles refer to list by precise leveling from Benecia (p. 13).

The leveling on Carquinez and Napa was done partly in 1896 under Mr. L. C. Fletcher, topographer, by Mr. J. A. Vogelson, levelman; partly in 1899 and 1900, under Mr. Fletcher by Mr. L. D. Ryus, levelman; and partly in 1906 under Mr. E. P. Davis, assistant topographer, by Mr. C. L. Nelson. The remainder of work herein listed was done in 1899 and 1900 under Mr. Fletcher by Mr. Ryus.

CARQUINEZ 15′ (NAPA 30′) QUADRANGLE.

SELBY, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO MARTINEZ.

	Feet.
Port Costa, in middle of concrete column of Karquinez Market Building on Main street, near station, opposite Burlington Hotel; bronze tablet stamped "17"	16.787

	Feet.
Martinez (U. S. Coast and Geodetic Survey bench mark), in brick front wall of the county building between the windows of the county clerk's and the auditor's offices; copper bolt marked on the face with the letters "U.S.C. & G.S." cut into angles of a cross (elevation accepted as given by the U. S. Coast and Geodetic Survey above half-tide level at Army Point, near Benicia)	27,090
Martinez court-house, U. S. Geological Survey bench mark at same place as above; bronze tablet stamped "27"	27.082

BENICIA, NORTHWEST TO VALLEJO.

Benicia arsenal, on brass cannon with muzzle down, used as a guard post at arsenal gate, marked "58"	58.098
Benicia schoolhouse, in southeast corner of foundation, east face, 2.5 feet above ground; bronze tablet stamped "35"	34.698
Vallejo and Sulphur Springs road, intersection with Vallejo-Benicia road, 3 miles west of Benicia, near corner of fence around Miller's ranch; iron post stamped "27 feet"	27.581
Vallejo, Sacramento street side of Bernard House, east of entrance, and 4 feet above sidewalk; bronze tablet stamped "44"	43.920

THREEMILE HOUSE, EAST TO LAKE CHABOT.

Lake Chabot, 0.5 mile east of, on Sulphur Springs road, 2.5 miles east of Threemile House, at bend of road between American Canyon road and cut-off road to Vallejo, at southwest corner of right-angle turn in road; iron post stamped "114"	113.678

NAPA JUNCTION, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO FAIRFIELD.

Creston station, on main east and west road north of railroad, on south side just east of northeast fence corner; iron post stamped "306"	306.272
Cordelia, intersection of Main street with road to Benicia, north of railroad, on south line of Main street near western side of Benicia road; iron post stamped "29 feet"	28.741
Fairfield court-house, 7.5 feet below bottom of stone ledge to first window of auditor's office, left of main entrance; bronze tablet stamped "15"	15.170

CORDELIA, NORTH UP GREEN VALLEY ROAD, TO NIGHTINGALE'S STONE HOUSE.

Nightingale's stone house, 3 miles from, in Green Valley, at northwest angle of road; iron post stamped "39"	39.171

CORDELIA, SOUTH ALONG ROAD AND SOUTHERN PACIFIC RAILROAD, TO BENICIA.

Cook's ranch, east side of road just north of bridge; iron post stamped "21"	20.702
Goodyear station, 1.5 miles north of schoolhouse, on west side of road south of stile; iron post stamped "17"	17.427

FAIRFIELD, WEST ALONG ROAD TO ROCKVILLE; THENCE SOUTH TO CORDELIA.

Rockville, northeast corner of crossroads, within fence corner, opposite saloon; iron post stamped "60 B"	60.144

POINT 2.8 MILES WEST OF FAIRFIELD, SOUTH TO ROAD FORK 0.5 MILE WEST OF PERRY'S HOUSE.

	Feet.
Perry's house, 0.5 mile west of; at road fork east of lane, south side of main road, in field; iron post stamped "25 B"	25.094

NAPA 30′ QUADRANGLE.

SOBRANTE, NORTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO SELBY.

Rodeo, 180 feet west of station, south side of track, in sandstone face of railroad cut; copper bolt stamped "U.S.G.S. B.M."	42.665

VALLEJO, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO NAPA JUNCTION.

Napa Junction, across tracks from hotel, near fence, on line between corral and section house, near gate leading to county road; iron post stamped "70"	69.942

ROCKVILLE, NORTHEAST ALONG ROAD, TO SCARLETT'S HOUSE NEAR MANKA.

Rockville, 2.8 miles northeast of, east side of road forks, 350 feet northeast of Sam Scarlett's house, in orchard; iron post stamped "88 B"	88.137

FAIRFIELD, NORTH ALONG COUNTY ROAD, TO LAGUNA CREEK; THENCE EAST TO VACAVILLE.

Tolenas Springs, fork of road, south side of gate; iron post stamped "205"	205.323
C. H. Steinmetz orchard, 400 feet east of southwest corner, in solid sandstone ledge north of bend in road; copper bolt stamped "U.S. G.S. 280 Ft. B.M."	279.658

VACAVILLE, WEST AND NORTH ALONG VACA AND PLEASANT VALLEY, TO WINTERS.

Alamo school, 30 feet northwest of woodshed, in grounds; iron post stamped "266"	265.555
Oakdale school, northwest corner of grounds; iron post stamped "426"	426.308
Pleasant Valley school, southeast corner of grounds; iron post stamped "257"	256.689
Winters, 4.5 miles southwest of, north side of road, 300 feet west of house of old Finch place; iron post stamped "169"	169.328

POINT 2.5 MILES WEST TO POINT 4.5 MILES WEST OF WINTERS, ON PUTAH CREEK.

Winters, 4.5 miles west of, in northwest corner of stone culvert over ravine at old Seely place; copper bolt stamped "U. S. G. S. 179 Feet B. M."	178.505

SAGE CREEK, AT MOUTH OF CHILES CREEK, SEC. 6, T. 7 N., R. 4 W.

Sage Creek, at mouth of Chiles Creek, west side of bridge, in ledge of rock forming north abutment; copper bolt stamped "U. S. G. S. 280 Feet B. M."	279.516

ST. HELENA, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO NAPA JUNCTION.

St. Helena, 0.5 mile south of; top of rail at switch to winery	236.0
Ink's house, 200 feet southeast of, 15 feet east of track, on right of way, 200 feet south of main road crossing; iron post stamped "176"	175.656

	Feet.
Oakville, 100 feet west and 50 feet south of station, at west side of grounds against fence; iron post stamped "153"	153.129
Yountville, 1 mile southwest of, in brick flue of electric-light plant at Veterans' Home, 5 feet above ground; bronze tablet stamped "165"	165.012
Magnolia; top of rail at switch	90.0
Trubody, in front of station; top of rail	84.0
Oak Knoll school, 30 feet northwest of, in grounds next to fence; iron post stamped "100"	99.558
Oak Knoll, in front of station; top of rail	106.0
Union, opposite station, west side of road at fence; iron post stamped "75"	75.449
Napa, in front of station; top of rail	15.1
Napa, in wall at northeast corner of court-house, facing Broom street, 1 foot south of corner stone, 3.7 feet above walk; bronze tablet stamped "20"	20.469
Lone Tree farm, in front of station; top of rail	7.1
Thompson; top of rail at switch	7.1
Thompson station, east of railroad, south end of switch, near switch block; iron post stamped "9"	8.972

CORDELIA, NORTH ALONG COUNTY ROAD, TO J. W. REAM'S RANCH ABOUT 1 MILE NORTH OF COUNTY LINE.

T. 6 N., R. 3 W., about northeast corner of sec. 36 (in Chimiles unsectionized grant), about 1 mile north of county line, north side of road, 125 feet east of gate to J. W. Ream's house; iron post stamped "228"	227.962

MOUTH OF SODA CREEK, SOUTH UP CAPELL VALLEY, TO CAPELL.

Burrow's house, 300 feet south of, in ledge in sidehill, south side of ravine, and west of road; copper bolt marked "U. S. G. S. 641 B. M."	641.059
Capell, 1,200 feet west of post-office, 300 feet west of forks of road, in rocky bluff; copper bolt stamped "U. S. G. S. 872 Ft. B. M."	872.183

ST. HELENA, SOUTH 1 MILE ALONG COUNTY ROAD, TO MOUTH OF SULPHUR SPRINGS CANYON.

St. Helena, 1 mile south of, north side of road, against fence at center of curve, 600 feet west of northwest corner of cemetery; iron post stamped "299"	299.033

YOUNTVILLE, NORTHEAST 2 MILES ALONG CAYMUS YAJOME GRANT BOUNDARY ROAD, TO CORNER.

Yountville, 2 miles northeast of, against fence on north side of road, 300 feet from forks; iron post stamped "142"	141.847

NAPA, NORTHEAST ALONG COUNTY ROAD, TO CEDAR KNOLL FARM, TULUCAY GRANT.

Cedar Knoll farm, in stone gatepost at entrance; bronze tablet stamped "155"	155.081

NAPA, EAST ALONG ROAD VIA INSANE ASYLUM, TO HARMONY SCHOOL.

Napa Insane Asylum, 1 mile east of; chisel mark on top of Coast and Geodetic Survey monument	123.56
Harmony school, 100 feet south of, 4 feet from fence; iron post stamped "121"	121.091

NAPA, WESTERLY ALONG ROAD VIA BROWN VALLEY, TO VINEYARD.

	Feet.
Huichica school, west side of grounds, 4 feet from fence, at west side of ravine; iron post stamped "217"	217.340
Vineyard, north end of station; top of rail	49.0

VINEYARD, NORTHWEST ALONG CALIFORNIA AND NORTHWESTERN RAILWAY, TO AGUA CALIENTE.

Sonoma, at First and Napa streets, in side wall of F. Deloring & Co.'s store, 2.7 feet above sidewalk and 5 feet north of rear door; bronze tablet stamped "83"	82.565
Sonoma, in front of station; top of rail	97.0
Caliente, in front of station; top of rail	130.0

SONOMA, NORTHEAST TO SEC. 31, T. 6 N., R. 5 W.

Sonoma, 2 miles east of, in ledge 4 feet high projecting from bank, 4 feet east of bank of ravine, 100 feet north and 150 feet west of road; aluminum tablet stamped "U.S.G.S. 232 Ft. B.M."	231.759

VINEYARD, SOUTH ALONG CALIFORNIA NORTHWESTERN RAILWAY, TO PETALUMA CREEK.

Junction of Southern Pacific and California Northwestern railroads; top of rail	12.
McGill, 600 feet northeast of, 400 feet northeast of bunk house; iron post stamped "7"	6.654
Fairville, 1 mile west of, on north bank of Tolay Creek, at foot of hill, opposite dairy buildings; iron post stamped "40"	39.676
Sears Point, 150 feet west of, at north side of road, opposite drawbridge; iron post stamped "13"	13.292
Reclamation, 2 miles east of, in levee 100 feet east of old railroad grade, at locks; iron post stamped "6"	5.121
Black Point, at drawbridge over Petaluma Creek, at southwest corner of bridge tender's house; iron T rail set in ground (U.S.C. &G.S. B.M. 14.581 above lower low tide)	10.623

SONOMA, SOUTHWEST, TO WETMORE SCHOOLHOUSE.

Sonoma, 2.5 miles southwest of, Watmaugh schoolhouse, at southwest corner of grounds, 20 feet from south fence; iron post stamped "68"	67.685

SANTA ROSA QUADRANGLE.

CALIENTE, NORTHWEST ALONG CALIFORNIA AND NORTHWESTERN RAILWAY, TO GLEN ELLEN; THENCE NORTHWEST ALONG COUNTY ROAD, TO SANTA ROSA; THENCE NORTH TO GWYN CORNER.

Sonoma, in front of station; top of rail	97.0
Caliente, in front of station; top of rail	130.0
Yulupa station, at junction with Southern Pacific Railroad; top of rail	165.0
Eldridge, in front of station; top of rail	191.0
California Home for Feeble Minded, in granite capstone at south end of entrance to Bentley Hall; bronze tablet stamped "234"	234.390
Glen Ellen, in front of station; top of rail	227.0
Dunbar school, 25 feet north and 100 feet west of, in ground near fence; iron post stamped "350"	350.415
Wildwood, in front of station; top of rail	408.0

	Feet.
Kenwood public school, northeast corner of grounds; iron post stamped "412"	412.335
Melitta, 125 feet east of post-office, northeast side of road, 125 feet north of bridge; iron post stamped "319"	319.211
Santa Rosa, 2 miles east of, 150 feet west of pumping station, south of road; iron post stamped "203"	202.947
Santa Rosa, in north wall of court-house, 2.5 feet above pavement, at west side of steps leading to second floor, 23 feet from entrance on Fourth street side; bronze tablet stamped "165"	164.977

SANTA ROSA, SOUTHEAST ALONG CALIFORNIA NORTHWESTERN RAILWAY, TO PETALUMA.

	Feet.
Wilfred, 2 miles west of, 300 feet east of Santa Rosa and Petaluma public road, opposite road to Cotata Land Company's pasture, at northeast corner of vineyard, in ledge on side of hill; aluminum tablet stamped "215"	214.914
Cotata, in front of station; top of rail	115.
Cotata, 1,000 feet south of station, 300 feet south of warehouse, west side of track, against fence at edge of right of way; iron post stamped "117"	117.466
Ely, halfway between north and south end of siding, east side of railroad right of way; iron post stamped "39"	39.282
Corona, at road crossing; top of rail	31.

PETALUMA, SOUTHEASTERLY ALONG CALIFORNIA AND NORTHWESTERN RAILWAY, TO LAKEVILLE; THENCE NORTHEAST ALONG COUNTY ROADS TO WATMAUGH SCHOOLHOUSE.

	Feet.
Lakeville schoolhouse, on schoolhouse grounds 150 feet north of building, 125 feet east of northwest corner; iron post stamped "53"	53.903
Eureka schoolhouse, at northwest corner of school yard; iron post stamped "277"	276.436

GWYNS CORNERS, WEST ALONG CALIFORNIA NORTHWESTERN RAILWAY, TO FORESTVILLE.

	Feet.
Olivet, in front of station; top of rail	76.
Fulton, 4 miles west of, in curve, 0.5 mile north of bridge over Laguna Creek, north of track, against fence; iron post stamped "70"	69.937
Trenton, in front of station; top of rail	50.
Forestville, 150 feet west of station, 90 feet south of main track, 30 feet north of siding; iron post stamped "58"	57.886

RUSSIAN RIVER, VIA NORTHWESTERN PACIFIC RAILROAD, TO SAN GERONIMO.

	Feet.
Russian River station, 3,5 miles south of, 3.5 miles north of Occidental, 200 feet north of bridge over Howard Creek, 100 feet north of point of hill, west of track, in projecting ledge of rock; aluminum tablet stamped "184"	184.116
Occidental, in front of station; top of rail	570.3
Occidental, 0.25 mile south of, 400 feet west of Meeker schoolhouse, east of track, at point of hill; iron post stamped "562"	562.188
Freestone, in front of station; top of rail	220.
Freestone, 0.5 mile east of, 0.25 mile east of Freestone district school north side of Sebastopol road, south of house, in orchard against fence; iron post stamped "290"	290.202
Bodega Roads, in front of station; top of rail	175.
Valley Ford, in front of station; top of rail	43.

	Feet.
Valley Ford, 1.5 miles southeast of, 500 feet south of creek at curve, on west side of Petaluma and Valley Ford road, near fence; iron post stamped "39"	38.945
Valley Ford, 2 miles southwest of, dairy at point of hill on Valley Ford and Tomales road, 500 feet west of, west side of Northwestern Pacific track, at south side of road crossing; iron post stamped "138"	138.595
Griffin, in front of station; top of rail	69.
Tomales, 2 miles northeast of, 0.5 mile north of Tomales tunnel, at point of hill east of track, at north end of cut; iron post stamped "118"	117.857
Tomales, 500 feet south of station, on bank opposite north edge of right of way; iron post stamped "113"	113.697
Tomales, 2.25 miles south of, east side of road at point of hill opposite mouth of canyon across bay or channel of tide flats, set in rock bluff; aluminum tablet stamped "5"	5.110
Hamlet, in front of station; top of rail	7.
Marshall, 3 miles north of, 250 feet south of milepost 44, 50 feet south of small bridge, at east side of railroad right of way, in top of projecting ledge of rock; aluminum tablet stamped "9"	9.113
Marshall, 300 feet east of store and post-office, 200 feet north of Marshall Hotel, east side of siding on creek bank; iron post stamped "8"	8.637
Fisherman, in front of station; top of rail	5.0
Point Reyes, 500 feet north of station, 50 feet east of railroad at crossing, north side of public road; iron post stamped "29"	29.503
Point Reyes, in front of station; top of rail	30.
Point Reyes, 2.25 miles northeast of north bend, in front of Mr. Galger's house, 300 feet west of front gate, on north side of track, against hedge fence; iron post stamped "46"	46.832
Tocaloma, 400 feet north of station, 150 feet west of Paper Mill Creek, at south end of cut in bank, west of railroad track; iron post stamped "86"	86.068
Tocaloma, in front of station; top of rail	86.
Taylorville, in front of paper mill; top of rail	121.
Camp Taylor, in front of station; top of rail	137.
Camp Taylor, 300 feet north of bridge at Camp Taylor Hotel, 150 feet from Paper Mill Creek, 100 feet west of clubhouse, on east side of track; iron post stamped "137"	137.984
San Geronimo, 0.25 mile north of, at north end of small cut in point of hill, east of railroad against fence, on west side of road; iron post stamped "285"	285.970
San Geronimo, in front of station; top of rail	305.

SAN RAFAEL, NORTH ALONG SAN FRANCISCO AND NORTH PACIFIC RAILROAD, TO PETALUMA.

Novata, 600 feet south of, 600 feet north of Creamery, 100 feet south of switch at south end of siding, against fence at line of railroad right of way, west of track; iron post stamped "16"	17.088
Novata, in front of station; top of rail	11.0
Burdell, 125 feet north of station, 150 feet east of rock bluff; iron post stamped "7"	7.995
Petaluma, 3 miles south of, at point of hill 200 feet west of track, at foot of small knoll 30 feet west of marsh, 100 feet east of 4-foot rock projecting above ground; iron post stamped "5"	6.298

BODEGA STATION, VIA COUNTY ROAD, TO BODEGA.

	Feet.
Bodega station, 0.25 mile north of, north of intersection of Valley Fork road with Freestone and Bodega road, against fence, at Bodega road corner; iron post stamped "169"	169.318
Bodega schoolhouse, against division fence between schoolhouse and church, 30 feet southwest of building; iron post stamped "145"	145.405

POINT REYES STATION, VIA COUNTY ROAD, TO REGALLOS RANCH.

Point Reyes, 1.25 miles south of, on Olema road 400 feet east of slough, south side of road; iron post stamped "14"	14.726
Inverness, 1 mile west of, at foot of hill known as "Light-house Grade," against fence north of road, at gate; iron post stamped "12"	12.843
Inverness, 3 miles northwest of, 0.5 mile west of summit of hill, opposite gate to Mr. Regallos's ranch, south side of road; iron post stamped "202"	202.063

NOVATA, WEST ALONG COUNTY ROAD (3-MILE SPUR LINE).

Novata, 3 miles west of, in open space opposite and 1,000 feet south of point of hill, at south side of road, against fence; iron post stamped "108"	108.707

PETALUMA, VIA COUNTY ROAD, TO WILSON AND MARIN SCHOOLS.

Petaluma, City Hall, in wall of main building, 2 feet from northeast corner, facing Kentucky street, 1.9 feet above pavement; bronze tablet stamped "17"	16.700
Wilson schoolhouse, at southeast corner of school yard; iron post stamped "81"	80.664
Petaluma, 3 miles west of, 0.5 mile west of Marin schoolhouse, 0.5 mile north of public road running over ridge west from Petaluma, at foot of hill south side of canyon, 150 feet west of fence on township line, in sec. 1, T. 4, R. 8 W.; iron post stamped "248"	247.628

ELY, WEST ALONG COUNTY ROADS, TO LIBERTY SCHOOL.

Ely, 2.5 miles west of, Liberty schoolhouse, at south side of school grounds, opposite forks of road, opposite cemetery; iron post stamped "103"	102.765

BELLVIEW STATION, WEST ALONG COUNTY ROAD, TO TODD SCHOOL; THENCE SOUTH TO STONY POINT SCHOOL.

Todd district schoolhouse, at front fence, 20 feet south of gate; iron post stamped "92"	91.775
Stony Point district school, 50 feet south of building, set in ground against fence; iron post stamped "96"	96.217

SANTA ROSA, VIA CALIFORNIA NORTHWESTERN RAILROAD, TO SEBASTOPOL.

Santa Rosa, 3 miles west of, Wrights schoolhouse, at northwest corner of grounds; iron post stamped "93"	93.075
Sebastopol, 600 feet north of, opposite large warehouse, against fence, east of track; iron post stamped "63"	63.481

TAMALPAIS QUADRANGLE.

SAN GERONIMO, SOUTHEAST ALONG NORTH PACIFIC COAST RAILROAD, TO SAN RAFAEL.

	Feet.
Fairfax, in front of station; top of rail	109.0
San Rafael, North Shore Railway station, foot of northeast corner of shed over track, northeast corner of cap (Coast and Geodetic Survey bench mark, 12.175 feet above mean lower low tide)	7.799

GEYSERVILLE QUADRANGLE.

GWYNS CORNERS, NORTHEASTERLY, TO CALISTOGA; THENCE SOUTHEAST TO ST. HELENA.

Burk's sanitarium, 30 feet west of entrance, north side of road; iron post stamped "210"	210.350
Tarwater school, 0.1 mile southwest of, at west side of road forks; iron post stamped "490"	490.118
Tarwater Hill summit, east of road at fence in front of old cabin; iron post stamped "1050"	1,050.292
Franz Valley school, 1 mile northeast of, south of road at summit on county line; iron post stamped "970"	970.456
Calistoga, 25 feet west of southwest corner of Lincoln avenue and Main street, in sidewalk; iron post stamped "354"	353.679
Calistoga, 4 miles southeast of, in center of cap at east side of stone bridge over Ritchie Creek; bronze tablet stamped "338"	338.389

FORESTVILLE, NORTHWEST ALONG CALIFORNIA NORTHERN RAILWAY, TO HILTON; THENCE WEST TO GUERNEVILLE.

Mera Bell Park; rail at	59.
Camp Six, in front of station; top of rail	66.
Hilton post-office, in front of; top of rail	66.
Hilton post-office and station, 300 feet southwest of trestle, foot of T. P. Brown's orchard, at fence; iron post stamped "65"	65.095
Korbell, in front of station; top of rail	62.

GUERNEVILLE QUADRANGLE.

GUERNEVILLE, SOUTHWEST ALONG CALIFORNIA NORTHWESTERN RAILWAY, TO RUSSIAN RIVER.

Guerneville, 0.5 mile west of, 30 feet west of road, 50 feet from railroad, south of crossing 300 feet, at point of hill at bend of road; iron post stamped "46"	46.540
Guerneville Park, in front of station; top of rail	44.
Russian River, in front of station; top of rail	38.

RUSSIAN RIVER, WEST ALONG NORTH SHORE RAILROAD, TO KIDD CREEK STATION.

Mesa Grand, in front of station; top of rail	40.
Moscow Cottage; top of rail	34.
Duncan's mill, west of railroad company's hotel, 1,500 feet southwest of roundhouse, at point of hill, 100 feet west of county road, on side of hill, in projecting ledge of rock; aluminum tablet stamped "44"	44.051
Kidd Creek, 800 feet south of, 600 feet south of mouth of Kidd Creek, in side of hill west of track, in projecting ledge of rock; aluminum tablet stamped "53"	53.113

DUNCAN'S MILL, VIA CALIFORNIA NORTHWESTERN RAILWAY AND COUNTY ROAD, TO JENNER GULCH.

	Feet.
Duncan's mill, 3 miles west of, mouth of Willow Creek, 200 feet west of forks of wagon road, 125 feet northeast of track; iron post stamped "23"	23.228
Markhams post-office, 3 miles west of, 400 feet from Russian River, 100 feet north and 20 feet above wagon road, west side of Jenner Gulch, in ledge of rock projecting from hillside; aluminum tablet stamped "56"	56.009

BODEGA, WEST 3 MILES.

Bodega, 3 miles west of, 1,500 feet east of Mrs. Quinlan's house, 75 feet north of road opposite gulch; iron post stamped "88"	87.946

RIO VISTA AND VACAVILLE QUADRANGLES.

CONTRA COSTA, SACRAMENTO, SAN JOAQUIN, AND SOLANO COUNTIES.

The elevations in the following list are based upon the precise-level line Benicia to Sacramento, which crosses Vacaville quadrangle and are checked upon a gage bench mark at Black Diamond landing.

The leveling on Antioch, Courtland, and Rio Vista quadrangles was done partly in 1905 under Mr. R. B. Marshall, geographer, by Mr. R. A. Farmer, topographer, and partly in 1906 by C. L. Nelson, and some leveling on Antioch quadrangle was done in 1896 under Mr. L. C. Fletcher by Mr. J. A. Vogelson. The leveling on Vacaville quadrangle was done under Mr. Marshall, partly in 1904 by Messrs. R. A. Farmer and C. H. Semper and partly in 1905 by Mr. Farmer.

NOTE.—The elevations of certain bench marks on the Courtland and Rio Vista quadrangles have been corrected by the precise-level line run by L. F. Biggs in fall of 1907 from Sacramento down the river to west edge of Rio Vista quadrangle.

COURTLAND QUADRANGLE.

GLIDE GUN CLUB, SOUTH ALONG RIGHT SIDE OF SACRAMENTO RIVER, TO CLARKSBURG.

	Feet.
Glide Gun Club, 0.5 mile south of, on line between Glide and Content, 300 feet south of Manual Content's house, 150 feet west of levee, 20 feet south of southwest corner of woodhouse; iron post stamped "16 B"	16.012
Anton Fernaude's house, 40 feet from southeast corner of, west side of road, northeast corner of house lot; iron post stamped "21 B"	20.852
Clarksburg, 0.5 mile north of, 100 feet east of Merrit schoolhouse, inside of fence; iron post stamped "14 B"	14.263

TREMONT, EAST 4 MILES; THENCE SOUTH 6.5 MILES; THENCE EAST 2 MILES; THENCE SOUTH 3 MILES; THENCE WESTERLY TO BINGHAMTON.

Bulkey's ranch house, at southeast corner of yard, west side of road; iron post stamped "34 B"	34.123
Hance Timm's house, 400 feet southeast of, west side of road; iron post stamped "31 B"	31.334

	Feet.
Jud King's ranch house, 0.5 mile west of, southeast corner T. 7 N., R. 2 E., southeast corner of field; iron post stamped "21 B"	20.708
T. 6 N., R. 2 E., near northeast corner of sec. 24, southeast corner to pasture fence; iron post stamped "8 B"	7.409
T. 6 N., R. 2 E., 1 mile east by 0.25 mile north of Peters's house, southeast corner of field; iron post stamped "17 B"	17.121

JUD KING'S RANCH HOUSE, 2 MILES EAST (DOUBLE SPUR LINE).

Jud King's ranch house, 2 miles east of, on north and south fence line, 50 feet east of levee, 150 feet southeast of dead tree on levee; iron post stamped "9 B"	8.777

FORKS OF SUTLER AND STEAMBOAT SLOUGHS, NORTH VIA COURTLAND, TO CLARKSBURG.

Forks of Sutler and Steamboat sloughs, 0.7 mile north of, 0.25 mile northwest of H. M. Donaldson's ranch house, 300 feet west of Sutler Slough, in northwest corner of Orchard lot; iron post stamped "6 1906 BN"	5.916
Courtland, 2 miles north of, 20 feet east of road, 150 feet west of drainage canal, 260 feet north of levee; iron post stamped "10 1906 B N"	9.900
Clarksburg, 2.2 miles south of, 40 feet southeast of Ross House, west of road, 200 feet west of Sacramento River; iron post stamped "19 1906 B N"	19.006

COURTLAND, SOUTHEAST, TO WALNUT GROVE.

Courtland, 60 feet east of road, in south foundation of Baner, Miller & Newbert's store; aluminum tablet stamped "14 BN 1906"	13.755
Grand Island, at head of Steamboat Slough, 0.5 mile north of bridge; zero of gage at Kerchwak House	—4.398
Grand Island Bridge, north corner of bridge abutment; aluminum tablet stamped "20 B N 1906"	19.696
Schoolhouse, 100 feet southeast of, 0.25 mile northwest of pump house, at southeast corner of yard, west side of road; iron post stamped "—2 B N 1906"	—2.498
Grand Island Bridge, 3.5 miles south of, 250 feet southeast of E. B. King's house, 150 feet northeast of Sacramento River levee, 100 feet northwest of cross levee; iron post stamped "8 1906 BN"	7.851

VACAVILLE QUADRANGLE.

BINGHAMTON, WEST ALONG HIGHWAY, TO ELMIRA.

Binghamton post-office, 5 feet east of northeast corner of; iron post stamped "35 B"	34.569
T. 6 N., R. 1 E., near quarter corner between secs. 28 and 27, west side of road at southeast corner of field; iron post stamped "44 B"	43.783
Elmira, 200 feet north of, 40 feet west of track, 8 feet north of telegraph pole; iron post stamped "72 B"	72.247
Elmira, 1.7 miles north of, 33 feet east of track, 2 feet west of milepost 62; iron post stamped "62 B"	62.282

SEC. 36, T. 5 N., R. 1 E., NORTHEAST TO CENTER OF T. 6 N., R. 2 E.

	Feet.
T. 5 N., R. 1 E., northeast corner sec. 13, west side of road; iron post stamped "15 B"	14.669
Main Prairie, 200 feet north of old hotel, 100 feet west of barn, west side of road; iron post stamped "7 B"	7.037

CANNON, ALONG WAGON ROAD, TO TRIANGULATION STATION.

Triangulation station, 400 feet east of railroad, 0.5 mile northwest of Cannon; iron post stamped "163 B"	163.382

WINTERS, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO ELMIRA.

Wolfskill station, at signboard; top of east rail	123.8
Allendale, in front of station; top of west rail	119.9
Allendale, 350 feet south of signboard, west of track and south of road crossing, 10 feet north of telegraph pole; iron post stamped "117 B"	117.056
Hartley, 400 feet south of signboard at station, east side of track and north of road crossing; iron post stamped "115 B"	115.067
Violet, in front of station; top of west rail	139.1
Vacaville station, 350 feet west of track, north of street, 8 feet east of telephone pole, at corner of railroad lot; iron post stamped "164 B"	164.138
Vacaville, at northwest corner of public schoolhouse, 4 feet above ground; bronze tablet stamped "188 B"	187.717
Vacaville, in front of station; top of west rail	161.9
Elmira, 200 feet north of station, 40 feet west of track, 8 feet north of telephone pole; iron post stamped "72 B"	72.247
Elmira, 1.7 miles north of, 33 feet east of track, 2 feet west of milepost 62; iron post stamped "62 B"	62.282

TREMONT, WEST VIA CURRY SCHOOLHOUSE, TO NEAR WOLFKILL.

Curry school, at northwest angle of crossroads; iron post stamped "85 B 1904 2"	85.018
Curry school, 3.7 miles west of, southeast angle of crossroads; iron post stamped "103 B"	103.139

DIXON, WEST VIA COUNTY ROAD, TO ALLENDALE.

Dixon, 700 feet south of station, west of track, at road crossing, south of road, at corner of fence; iron post stamped "61 B"	61.295

ANTIOCH QUADRANGLE.

FAIRFIELD COURT-HOUSE, EAST ALONG WAGON ROAD, TO POINT 1 MILE NORTH OF DENVERTON; THENCE TO DENVERTON; THENCE EAST TO SEC. 36, T. 5 N., R. 1 E.

Fairfield court-house, 2.75 miles east of, 100 feet east of water tank, on south side of road; iron post stamped "15 B"	14.704
T. 5 N., R. 1 W., sec. 29, southeast corner of (set probably in 1896)	14.788
Denverton, 5 feet west of northwest corner of blacksmith shop, in front of schoolhouse; iron post stamped "7 B"	6.564
T. 5 N., R. 1 E., northeast corner sec. 36, east side of road; iron post stamped "17 B"	17.261

SEC. 29, T. 5 N., R. 1 W., SOUTH TO POTRERO HILLS.

	Feet.
Potrero Hills, on section line between secs. 3 and 4, 0.5 mile south of north line of section, opposite gate to Sylvester Pimental's ranch, 5.5 miles east to Suisun; iron post stamped "49"	49.064

DENVERTON, SOUTH ALONG WAGON ROAD, TO NEAR BIRDS LANDING; THENCE EASTERLY TO PETER ANDERSON'S PLACE.

Montezuma schoolhouse, southeast corner of yard, west of road; iron post stamped "41 B"	41.245
Willow Springs schoolhouse, southeast corner of yard, west side of road; iron post stamped "58 B"	57.666
Birds Landing, 5 miles southeast of, at Peter Anderson's place, 10 feet west of gate to barn, on south side of road; iron post stamped "110 B"	110.131

SEC. 35, T. 5 N., R. 1 E., SOUTHEAST TO SEC. 9, T. 4 N., R. 2 E.

T. 4 N., R. 2 E., corner secs. 3, 4, 9, and 10, 300 feet southwest of M. Egbert's white house, west side of road; iron post stamped "32 B"	31.957

CONCORD, NORTH ALONG ROAD TO BAY POINT; THENCE EAST ALONG SOUTHERN PACIFIC RAILROAD, TO BLACK DIAMOND.

McAvoys siding, in corner of fence southwest from southwest corner of warehouse; iron post stamped "22"	22.439
Black Diamond, at corner of stable; iron post stamped "21"	20.500
Black Diamond Hotel, tack on porch of, midway between two doors, 4 inches from side of house[a]	7.500

CORNWALL, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO ANTIOCH.

Antioch schoolhouse, in rear wall of foundation; bronze tablet stamped "35"	35.296
Antioch, in front of station; top of rail	43.5

SIX MILES SOUTHWEST OF RIO VISTA, EAST AND SOUTH ALONG ROAD, TO TOLANDS LANDING; THENCE WEST TO FORKS OF ROAD 1.5 MILES SOUTH OF BIRDS LANDING.

Tolands Landing, 3 miles west of, north side of road, 1 foot south of fence line, 8 feet east of gate, 0.25 mile west of feeding shed, 100 feet north of slough; iron post stamped "10 B"	9.874
Collinsville, 0.5 mile north of, southwest corner of schoolhouse, at crossroads; iron post stamped "5 B"	4.927

TOLANDS LANDING, SOUTH ACROSS SHERMAN ISLAND, TO NORTH BANK SAN JOAQUIN RIVER; THENCE WEST TO ANTIOCH.

Tolands Landing, 3.9 miles south of, at south end of road which crosses Sherman Island southward from Tolands Landing, at turn, 0.5 mile south from pump house, 100 feet north of San Joaquin River, south side of road, 0.25 mile east of house; iron post stamped "—1 1906 BN"	—1.477

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[a] The above bench mark is, as nearly as could be determined, the datum of the level system of the State engineering department, the elevation of which above the mean "lowest low tide," as resulting from tidal observations made at New York Landing during the months of October, November, and December, 1878, is 11.22 feet. From tide tables, mean sea level is 3.7 above lowest low water at Antioch.

RIO VISTA QUADRANGLE.

ANDERSON'S PLACE, NORTHEAST TO RIO VISTA; THENCE NORTHWEST TO NORTHEAST CORNER SEC. 9, T. 4 N., R. 2 E.

	Feet.
Madison's blacksmith shop, 100 feet from southwest corner of, northwest corner of field, and east side of road; iron post stamped "54 B"	53.822
Rio Vista Bank Building, southeast corner, 2 feet above sidewalk; tablet stamped "23 B"	22.425
T. 4 N., R. 2 E., corner secs. 11, 12, 13, and 14, east side of road; iron post stamped "19 B"	18.900

RIO VISTA, NORTH BY STEAMBOAT SLOUGH AND SUTTER SLOUGH, TO FORK OF SUTTER AND STEAMBOAT SLOUGH.

Ferry landing; zero of gage	—4.403
Rio Vista, 3.7 miles north of, 0.8 mile south of Westgates, 250 feet west of river, 200 feet west of house on north side of road; iron post stamped "—1 B N 1906"	—1.130
Walkers Landing, 0.7 mile north of, west side of road, 150 feet west of Steamboat Slough, 250 feet northwest of J. Hollenbeck's house; iron post stamped "4 1906 B N"	3.600

WALNUT GROVE, SOUTH ALONG EAST SIDE TYLER ISLAND AND WEST, TO RIO VISTA.

Tyler Island, east side of road across island, 200 feet west of Mokelumne River, on ranch "J" of Bamman property, 0.25 mile south of pump house; iron post stamped "—1 N 1906"	—1.088
Camp C, 140 feet east of house, 100 feet north of Mokelumne River, 100 feet northwest of barn; iron post stamped "0 1906 B N"	—0.282
Ferry landing to Tyler Island, 150 feet west of, north side of road, 50 feet west of saloon; iron post stamped "3 1906 B N"	3.040
G. F. Terschman's house, 85 feet west of, 200 feet south of Sacramento River; iron post stamped "5 B N 1906"	4.943

CAPAY, DAVISVILLE, DUNNIGAN, FAIROAKS, KNIGHTS LANDING, POPE VALLEY, RUMSEY, AND WOODLAND QUADRANGLES.

COLUSA, NAPA, PLACER, SACRAMENTO, SUTTER, AND YOLO COUNTIES.

The elevations in the following list are based upon the precise-level lines along the Southern Pacific Railroad from Benicia via Sacramento to Mohave and from Davisville north to State line.

The leveling on Fairoaks quadrangle was done in 1901 under Mr. A. E. Murlin, topographer, by Mr. L. D. Ryus, levelman, and that on Davisville quadrangle was done in 1905 under Mr. R. B. Marshall, geographer, mostly by Mr. G. C. Douglas, levelman, but partly by R. A. Farmer, topographer. The leveling on the Woodland quadrangle was done in 1904 by Messrs. Farmer and C. H. Semper.

The work on Dunnigan quadrangle was done in 1904 by Mr. Semper, that on Knights Landing quadrangle was done in 1904 by

Mr. Semper and in 1905 by Mr. Douglas, and that on Rumsey quadrangle in 1904 by Messrs. Farmer and E. M. Fry. That on Capay and remainder of Pope Valley 30′ quadrangle was done under Mr. L. C. Fletcher, partly in 1899 by L. D. Ryus, levelman, and partly in 1904 by Mr. Farmer.

FAIROAKS QUADRANGLE.

SACRAMENTO, NORTHEAST TO SAN JUAN SCHOOL; THENCE TO FAIROAKS; THENCE SOUTH TO SOUDAN; THENCE SOUTHWEST ALONG SOUTHERN PACIFIC RAILROAD TO ROUTIER; THENCE SOUTH TO WALSH STATION; THENCE NORTHWEST ALONG SOUTHERN PACIFIC RAILROAD, TO BRIGHTON.

	Feet.
Sacramento, in north wall of post-office, 15 feet east of northwest corner, 5 feet above ground; aluminum tablet stamped "31 B"	30.527
Sacramento, State capitol, 3 miles northeast of, at intersection of roads; iron post stamped "39 B"	39.320
Ben Ali, 2.5 miles east of, 150 feet west of windmill, at intersection of roads; iron post stamped "69 B"	68.650
San Juan schoolhouse, 1 mile east of, at southeast corner of field, at intersection of roads; iron post stamped "191 B"	190.625
Fairoaks Junction, 300 feet east of switch, at southeast corner of field, north of track; iron post stamped "113 B"	112.937
Routier, opposite station, north of county road; iron post stamped "69 B"	68.754
Walsh, at southwest corner of field, opposite saloon; iron post stamped "64 B"	63.937

SACRAMENTO, NORTH ALONG MARYSVILLE ROAD, TO FORKS OF ROADS AT NORTHWEST CORNER OF SEC. 19, T. 10 N., R. 5 E.; THENCE EAST TO QUARTER CORNER SOUTH SIDE OF SECTION 10, T. 10 N., R. 6 E.; THENCE SOUTHERLY TO FAIROAKS.

Sacramento Capitol, 5 miles north of, 250 feet north of house, 100 feet west of corner at L of road; iron post stamped "28 B"	27.933
T. 10 N., R. 5 E., northwest corner of sec. 19, at intersection of road running east from main road; iron post stamped "31 B"	30.862
T. 10 N., R. 5 E., southwest corner of sec. 13, 1 mile south of Centre Union schoolhouse, east side of road, at angle to north; iron post stamped "89 B"	88.898
Antelope, 2 miles northeast of, at edge of Southern Pacific Railroad right of way, north of road at crossing, west of track; iron post stamped "146 B"	146.101
T. 10 N., R. 6 E., near center sec. 25, at southeast corner of cross-roads; iron post stamped "151 B"	151.212

DAVISVILLE QUADRANGLE.

SACRAMENTO, NORTHWEST ALONG HIGHWAY, TO WOODLAND.

Sacramento, west of, south side of track at milepost 86; iron post stamped "17 B"	17.339
Elkhorn, 7.7 miles south of, water tank on east side of levee road, in front of Lehman's hop yard, 3 feet north of foundation to tank; iron post stamped "32 B"	32.138
Elkhorn, 3.9 miles south of, northwest corner of foundation to Taylor monument; small cross cut in granite block set in brick, marked "U. S. G. S. 29"	28.87

	Feet.
Elkhorn, 2.8 miles south of, west corner cement-foundation water tank on levee opposite John Merkley's place; aluminum tablet stamped "32 B"	32.015
Elkhorn, southwest corner of stone house by watering trough, on road to Woodland; iron post stamped "27 B"	26.785
Elkhorn, 3.6 miles west of, south side of road, 340 feet east of section corner; iron post stamped "23 B"	23.035

AT GRAYS BEND.

Knights Landing, 6.1 miles southeast of, 200 feet northwest of Mr. Weisman's house at Grays Bend, west side of road, at foot of levee; iron post stamped "29 B"	29.163

ELKHORN WEIR TO ELKHORN.

Elkhorn, 3 miles north of, 400 feet north of Dillon's house, 50 feet west of levee, on fence line; stone monument (U. S. B. M. 69)	25.539
Elkhorn, 2.9 miles north of, 200 feet south of Dillon's house, at north end of Elkhorn Weir, top of west end of wall; aluminum tablet stamped "30 B"	30.000
Elkhorn, 2.9 miles north of, 60 feet south of Dillon's house, stone monument (U. S. B. M. 70)	29.99

SACRAMENTO, SOUTH ON RIGHT BANK OF SACRAMENTO RIVER, TO GLIDE GUN CLUB.

Broderick, 3 miles south of, west side of road in front of hop storage house of Perry's place, iron post stamped "29 B" [a]	28.671
Machardo's house, 300 feet south of, 20 feet south of road; iron post stamped "22 B" [a]	22.315

WOODLAND QUADRANGLE.

YOLO, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO WOODLAND.

Yolo, 150 feet north of station, north of road; iron post stamped "74 B"	72.922
Yolo, 0.8 mile south of, north abutment of bridge over Cache Creek, west end, top of parapet wall; aluminum tablet stamped "89 B"	89.425
Woodland, 2.2 miles north of, north of road, 250 feet east of track, at southwest corner of Taylor Bros.' farm; iron post stamped "64 B"	63.986
Woodland, at Southern Pacific Railroad station, southeast corner of railroad park, 5 feet north of water tank; iron post stamped "60 B"	60.260
Woodland, southeast corner of Yolo County Savings Bank; aluminum tablet stamped "71 B"	70.734

YOLO, WEST VIA COUNTY ROAD, TO FORKS OF ROAD 1 MILE WEST OF BLICKLEY RANCH.

Yolo, 3.9 miles west of, on north of road at gate leading to Fred Market's ranch house; iron post stamped "169 B"	169.283
Yolo, 7.4 miles west of, at southeast angle of crossroads, 650 feet south of J. C. Holverstott's ranch house; iron post stamped "169 B"	169.168

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[a] Elevation corrected by precise-level line of L. F. Biggs in fall of 1907.

WOODLAND, WEST, TO MADISON.

	Feet.
Woodland station, 8 feet north of water tank; iron post stamped "60 B"	60.260
Woodland, 4.4 miles west of, in south face of northwest monument Yolo Base, U. S. Coast and Geodetic Survey, stamped "155 B"	155.033
Woodland, 5 miles west of, on east line of Guersisosi grant; iron post stamped "108 B"	108.011
Madison, in front of station; top of east rail	143.5
Madison, 200 feet southwest of station, south of Main street, 8 feet west of telephone pole; iron post stamped "150 B"	150.026

MADISON, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO WINTERS.

Citrona, in front of station; top of west rail	162.6
Citrona, 60 feet west of warehouse, west side of road; iron post stamped "162 B"	162.056
Ely in front of station; top of west rail	174.0
Ely, 100 feet west of warehouse, 60 feet west of signboard, west side of road; iron post stamped "175 B"	175.004
Winters, 200 feet south of station, 40 feet west of track, 50 feet east of street; iron post stamped "131 B"	131.011
Winters, in front of station; top of west rail	130.9

FRENCH PLACE, NORTHEAST, TO WINTERS AND RETURN.

Winters, 10 feet from fence, at west side of public school grounds; iron post stamped "133 B"	132.843

3.2 MILES NORTH OF DAVISVILLE, WEST ALONG COUNTY ROAD, TO ELY.

Davisville, 3.2 miles north of, 30 feet north of milepost 80; iron post stamped "48 B"	48.400
Plainfield, southeast angle of crossroads; iron post stamped "70 B"	69.932
Plainfield, 3 miles west of, at signboard, northwest angle of crossroads; iron post stamped "90 B"	90.131

CROSSROADS 3 MILES WEST OF PLAINFIELD, NORTH ALONG COUNTY ROAD, TO NORTHWEST MONUMENT COAST AND GEODETIC SURVEY, YOLO BASE.

Stoddard schoolhouse, 3.4 miles north of, at northeast angle of crossroads; iron post stamped "96 B"	95.942

CROSSROADS 3 MILES WEST OF PLAINFIELD, SOUTH VIA COUNTY ROAD TO CURRY SCHOOLHOUSE.

Fairfield schoolhouse, 1 mile south of, northeast angle of crossroads, at fence; iron post stamped "92 B"	91.853

ONE MILE SOUTH OF FAIRFIELD SCHOOLHOUSE, EAST AND SOUTH, TO COAST AND GEODETIC SURVEY MONUMENT.

Miller ranch, north bank of Putah creek, Coast and Geodetic Survey monument, north face; aluminum tablet stamped "74 B"	73.901

CAPAY (POPE VALLEY 30′) QUADRANGLE.

POINT 4.5 MILES WEST OF WINTERS, WESTERLY, TO SODA CREEK.

Corner stone, Yolo, Solano, and Napa counties, north bank of Putah Creek, on bench east side of rock 3 inches below top; copper bolt stamped "U. S. G. S. 212 Ft. B. M."	212.272
Wragg Canyon, east of, at fork of road; iron post stamped "306"	306.128

	Feet.
Monticello, 1.25 miles south of, in top of stone tablet in center of south side of Monticello stone bridge over Putah Creek; bronze tablet stamped "309"	308.643

TANCRED, SOUTH, TO CAPAY.

Cadnassa, 400 feet north of station, east of track, on right of way line, at northwest corner of field; iron post stamped "333 B"	333.354
Capay, in front of station; top of south rail	215.0

SEC. 36, T. 11 N., R. 2 W., SOUTH TO CAPAY.

Intersection of Capay-Grant range line between Rs. 1 and 2 W., 10 feet north of; iron post stamped "191 B"	191.216

MADISON, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO CAPAY.

Esparto, southeast corner of post-office building, 18 inches above ground, in east wall, 18 feet south of corner; tablet stamped "190 B"	190.047
Capay, southeast corner of yard limits, north side of Main street, west of road from Dunnigan; iron post stamped "203 B"	203.432

RUMSEY (POPE VALLEY 30′) QUADRANGLE.

ARBUCKLE, SOUTHEAST, TO HERSHEY.

Arbuckle, 4.6 miles south of, east of track at road crossing, 1,100 feet north of milepost 110, at Widow Spencer's ranch; iron post stamped "139 B"	138.694

CORNER TS. 13 AND 14 N., RS. 2 AND 3 W., SOUTH AND EAST TO DUNNIGAN.

Liggett ranch house, 0.5 mile west of, 50 feet northwest of northwest corner sec. 16, T. 13 N., R. 3 W., 100 feet south of creek, north side of road; iron post stamped "308 B"	308.027
Wildwood schoolhouse, 50 feet northwest of, 20 feet south of county line, between Yolo and Colusa counties; iron post stamped "304 B"	304.147
Dunnigan, 2 miles north by 3 miles west of, 300 feet north of creek, 150 feet northeast of house, 5 feet east of gate; iron post stamped "195 B"	195.168

SAND CREEK SCHOOLHOUSE, SOUTHWEST ALONG ROAD VIA OLD OIL WELLS, TO RUMSEY.

Old oil wells, 400 feet north of, 400 feet northwest of old stock shed, 10 feet north of road, 50 feet north of Sand Creek; iron post stamped "583 B"	583.109
Rumsey, 4 miles north of, on summit of divide between Cache and Sand creeks, 10 feet east of road; iron post stamped "1350 B"	1,350.121

RUMSEY, VIA SOUTHERN PACIFIC RAILROAD, TO TANCRED.

Rumsey, in front of station; top of east rail	419.1
Rumsey, 250 feet southeast of station, 100 feet west of barn, on line between railroad and farm; iron post stamped "418 B"	418.292
Guinda, in front of station; top of rail	353.7
Guinda, 125 feet northwest of station, 60 feet southeast of hotel; iron post stamped "353 B"	353.240
Tancred, 120 feet north of station, 50 feet east of track; iron post stamped "296 B"	296.234

NEAR BRIMLEY'S RANCH, SOUTH ALONG ROAD TO NORTHWEST CORNER SEC. 36, T. 11 N., R. 2 W.

	Feet.
Fairview schoolhouse, 40 feet south of northwest corner of, 60 feet east of road; iron post stamped "342 B"	342.285
T. 11 N., R. 2 W., northwest corner sec. 36, 1 mile east of schoolhouse, northeast corner of field, southwest corner of crossroads, 4 feet south of corner post; iron post stamped "236 B"	236.686

POPE VALLEY 30′ QUADRANGLE.[a]

SODA CREEK, WEST-NORTHWEST TO NEAR MOONEY'S RANCH; THENCE SOUTHWESTERLY TO MOUTH OF CHILES CREEK.

Mooney's ranch, 1 mile west of, north side of road at summit, 100 feet west of road to Priet's house; iron post stamped "991"	991.170

SAGE CANYON, NORTH, TO CONN VALLEY SCHOOLHOUSE.

Conn Valley school, 40 feet north of southeast corner, in grounds near fence; iron post stamped "319"	319.235

MOUTH OF CHILES CREEK, NORTHWEST, TO BRIDGE 1 MILE NORTHEAST OF ST. HELENA; THENCE SOUTHWEST TO ST. HELENA.

St. Helena, 1.25 miles northeast of, in north wall, 25 feet east of west end of stone bridge over Napa Creek; bronze tablet stamped "221"	221.099
St. Helena, southwest corner of Main and Adam streets, in wall at north side of J. R. Kettlewell's hardware store, 1.7 feet above sidewalk, 1.5 feet from corner; bronze tablet stamped "255"	254.742

KNIGHTS LANDING QUADRANGLE.

ROUGH AND READY LANDING, SOUTHEAST ALONG RIVER ROAD, TO KNIGHTS LANDING STATION.

Derby Camp, 1.3 miles east of, north edge of river levee, opposite Chinese camp; iron post stamped "39 B"	39.432
Knights Landing, bridge over Sacramento River, top of south abutment, west wing wall, south end of; aluminum tablet stamped "41 B"	41.553
Knights Landing station, 30 feet east of track, at corner of road, opposite north side of station; iron post stamped "32 B"	31.825

KNIGHTS LANDING, SOUTH ALONG RIVER ROAD, TO GRAYS BEND.

Knights Landing, 4 miles southeast of, west side of road at foot of levee, south line of Mr. Roseberry's place; iron post stamped "30 B"	30.132

GRAYS BEND, EAST DOWN RIVER ROAD, TO ELKHORN WEIR.

Knights Landing, 10.6 miles southeast of, 0.25 mile north of Doyle's house, 40 feet west of junction of river road and lane, north side of road; iron post stamped "29 B"	28.958

DUNNIGAN QUADRANGLE.

HERSHEY, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO YOLO.

Hershey, 50 feet west of track, at road crossing 50 feet north of Colusa-Yolo County line; iron post stamped "137 B"	137.126
Dunnigan, 60 feet north of station, at edge of park fence; iron post stamped "67 B"	67.018

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[a] For additional elevations on Pope Valley quadrangle, see Capay and Rumsey 15′ quadrangles (pp. 144 and 145).

	Feet.
Dunnigan, 3.2 miles south of, 50 feet east of milepost 101, 60 feet east of track, at road crossing; iron post stamped "45 B"	44.955
Zamora (Blacks station post-office), 0.65 mile north of, 0.2 mile south of milepost 98, east of track at corner of fence on right of way at public road crossing, sec. 17, T. 11 N., R. 1 E.; iron post stamped "46 B"	45.841
Ronda station, east of track at corner of right-of-way fence at road crossing, near milepost 94.7; iron post stamped "54 B"	54.193

COLLEGE CITY, SOUTHEAST AND SOUTH, TO NEAR DUNNIGAN.

John's school, 1.1 miles north of, at fence at southeast angle of crossroads; iron post stamped "43 B"	43.017
Spanish ranch house, 1.6 miles north of, south side of county line, at entrance to ranch; iron post stamped "47 B"	47.024
Vombreyman's ranch, at fence line, northeast angle of road to north; iron post stamped "36 B"	35.702

SAM HINES RANCH, VIA HOWELL POINT, TO ROUGH AND READY LANDING.

Wilkins Slough school, at west end of fence, road in front of school; iron post stamped "32 B"	32.140
Wilkins Slough school, 2.3 miles south of, at road to J. M. Miller's ranch house; iron post stamped "34 B"	34.163
Howells Point, at entrance to landing, Yolo-Colusa County line; iron post stamped "37 B"	37.383
Howells Point, 1.8 miles south of, at gate leading to Ern Miller's ranch house; iron post stamped "31 B"	31.071
Rough and Ready Landing, at junction of canal and river, south side of canal, 40 feet west of large oil tank; iron post stamped "40 B"	40.633

KNIGHTS LANDING, WEST 4.9 MILES; THENCE NORTH TO ROUGH AND READY LANDING.

Blacks station post-office, 4.3 miles east of, at crossroads to Yolo and Grimes Landing, northeast corner angle of roads; iron post stamped "41 B"	41.177

ZAMORA (BLACKS STATION POST-OFFICE), EAST 4.3 MILES.

Blacks station post-office, 2.5 miles east of, at corner of gate to barnyard of F. Schliemann's ranch house; iron post stamped "49 B"	49.093

DUNNIGAN, SOUTHWEST AND SOUTH ALONG COUNTY ROAD, TO NEAR BRIMLEY RANCH.

Brimley ranch, 1 mile north of, summit between Dunnigan and Fairview schoolhouse, east side of road; iron post stamped "333 B"	333.203

COLUSA, FRUTO 30′, GRIMES, MAXWELL, SITES 30′, TEHAMA, VINA, AND WILLOWS QUADRANGLES.

COLUSA, GLENN, AND TEHAMA COUNTIES.

The elevations in the following list are based upon the precise-level line from Benicia north along the Southern Pacific Railroad to Oregon.

The leveling on Tehama and Vina quadrangles and part of that on Willows quadrangle was done in 1903 under Mr. R. B. Marshall, topographer, by Messrs. S. E. Blout and E. W. Glafcke, levelmen.

The remainder on Willows quadrangle was done in 1904 by Messrs. E. M. Fry and C. L. Nelson, levelmen, and that on remainder of Fruto 30′ quadrangle was done in 1904 by Mr. H. Hartley, levelman.

The leveling on Colusa, Grimes, and part of Maxwell quadrangles was done in 1904 by Messrs. C. H. Semper and E. M. Fry, levelmen; that on remainder of Maxwell quadrangle in 1904 by Mr. Hartley. The leveling on remainder of Sites 30′ quadrangle was done in 1904 by Messrs. Hartley and Fry.

MAXWELL QUADRANGLE.

WILLOWS, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO WOODLAND.

	Feet.
Willows, 3 miles south of, east side of road at milepost 148, at right of way fence; iron post stamped "111 B"	110.891
Logadale, at telegraph pole opposite milepost 145; iron post stamped "103 B"	102.000
Norman, 600 feet north of brick warehouse, on west side of road; iron post stamped "91 B"	91.325
Norman, 1.2 miles south of, 1,800 feet north of county line, east of road, at third telephone pole south of milepost 142; iron post stamped "90 B"	90.330
Delevan, northwest corner of right of way fence, at forks of road, at milepost 139; iron post stamped "95 B"	95.390
Maxwell, 2 miles north of, west of road, first telegraph pole south of milepost 136; iron post stamped "90 B"	89.608
Maxwell, 150 feet west of station, northeast corner of lot, south margine of Main street, at base of flag pole; iron post stamped "93 B"	93.332

POINT 3 MILES EAST OF WILLOWS, SOUTH AND WEST, TO NORMAN.

Willows, 4 miles south by 3 miles east of, at southwest corner of fence at forks of road; iron post stamped "97 B"	95.553
Willows, 6.4 miles south by 3 miles east of, east side of road at southeast corner of fence; iron post stamped "86 B"	83.884

NORMAN, EAST TO PRINCETON; THENCE NORTH TO GLENN.

Princeton, 3 miles west of, west of gate, 1 foot from fence at south side of road; iron post stamped "70 B"	70.239
Princeton, 1 foot north of north wall of brick building, used as general store and post-office, 3 feet west of well, 10 feet west of Commercial street; iron post stamped "80 B"	80.217
Princeton, 4 miles north of, 50 feet east of wagon bridge over canal, at fence corner, 30 feet southwest of crossroads; iron post stamped "86 B"	85.983

THREE MILES EAST OF NORMAN, SOUTH AND WEST TO MAXWELL.

Glenn, Colusa County line, 60 feet east of fence, T. 18 N., between Rs. 2 and 3 W.; iron post stamped "71 B"	69.217
Excelsior schoolhouse, 200 feet west of, on east side of road, at corner of schoolhouse; iron post stamped "62 B"	60.431
Maxwell, 4 miles east of, south side of road at forks; iron post stamped "56 B"	54.453

EXCELSIOR SCHOOLHOUSE, EAST ACROSS COUNTRY, TO COMPTON LANDING; THENCE NORTH TO PRINCETON.

	Feet.
Compton Landing, 0.2 mile south of, corner of fence at west side of road; iron post stamped "67 B"	67.147
Princeton, in front wall of brick store building (property of P. P. Tapscott) 5 feet south of door, east side of Commercial street; aluminum tablet stamped "83 B"	82.947

COMPTON LANDING, SOUTH TO COLUSA.

Colusa, 5 miles north of, 150 feet southwest of Sever's ranch house, 25 feet east of forks of road; iron post stamped "60 B"	60.229

FORKS OF ROADS 4 MILES WEST OF NORMAN, SOUTH 3 MILES; THENCE EAST 1 MILE.

Norman, 3 miles west by 3 miles south of, Lower Campbell ranch, northeast corner of bunk house, 400 feet northeast of water tank; iron post stamped "117 B"	117.070

GRIMES QUADRANGLE.

COLUSA, SOUTHEAST, TO SYCAMORE.

Sycamore, at east margin of highway, opposite saloon, between locust trees; iron post stamped "48 B"	48.129

FORKS OF ROAD 2.7 MILES SOUTH OF SYCAMORE, SOUTH AND WEST TO ARBUCKLE.

Grimes Landing, at northwest corner of Main and Second streets; iron post stamped "47 B"	47.089
Sam Hines' ranch, in northwest angle of roads; iron post stamped "32 B"	32.108
Hines (Sam), 2.6 miles west of, 145 feet west of levee, south of road; iron post stamped "26 B"	25.932
College City, 1.5 miles north and east of, 1,100 feet west of bridge over slough, at southeast angle of road to south; iron post stamped "36 B"	35.824

COLUSA (FRUTO 30′) QUADRANGLE.

COLUSA JUNCTION, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO ARBUCKLE.

Colusa Junction, 100 feet south of station, 300 feet north of railroad crossing, east of track; iron post stamped "79 B"	78.749
Williams, 2 miles north of, 60 feet west of track, north of road on line of right of way fence, at crossroads; iron post stamped "73 B"	73.338
Williams, 110 feet west of track, 125 feet northwest of station, south side of street; iron post stamped "79 B"	78.845
Williams, 4 miles south of, 250 feet south of milepost 121, fence corner at road crossing; iron post stamped "90 B"	89.605
Arbuckle, 2.4 miles north of, east of road, 100 feet west of track, at fence opposite milepost 117; iron post stamped "106 B"	106.394
Arbuckle, 130 feet west of, at base of 50-foot flagpole; iron post stamped "137 B"	136.683

COLUSA, WEST, TO COLUSA JUNCTION.

	Feet.
Colusa, 150 feet west of corner of Ninth and Market streets, 10 feet south of sidewalk, on south side of street, in city park; iron post stamped "58 B"	58.265
Colusa, north wall of Colusa County court-house, 15 feet west of main entrance; aluminum tablet stamped "60 B 1904"	60.375
Colusa, 3.5 miles west of, at south side of wagon road, 75 feet southeast of bridge over slough, 60 feet south of track; iron post stamped "51 B"	51.205

COLUSA JUNCTION, WEST, TO LURLINE.

	Feet.
Lurline station, 75 feet east of schoolhouse, 25 feet south of track, northwest corner of warehouse; iron post stamped "111 B"	111.023

ONE MILE NORTH OF WILLIAMS, WEST, TO FRESHWATER SCHOOLHOUSE.

	Feet.
Freshwater schoolhouse, 50 feet northwest of, south side of county road, 100 feet west of well; iron post stamped "121 B"	120.953

SYCAMORE, WEST, TO WILLIAMS.

	Feet.
Williams, 6.6 miles east of, at corner of fence west of high levee north of road; iron post stamped "39 B"	39.584
Williams, 3.4 miles east of, at southeast angle of crossroads, at line of fence; iron post stamped "56 B"	56.491

SYCAMORE, SOUTH AND WEST VIA COUNTY ROAD, TO BERLIN.

	Feet.
Dry Slough schoolhouse, 3 miles west of, at southeast angle of crossroads; iron post stamped "42 B"	42.125
Prize, 0.5 mile west of, south of road at road to north, 20 feet west of bridge; iron post stamped "51 B"	51.173

STORAL RANCH, SOUTHEAST TO CORTINA SCHOOLHOUSE; THENCE EAST TO BERLIN.

	Feet.
T. 15 N., R. 3 W., southeast corner sec. 32, 0.5 mile north by 0.5 mile east of Montgomery ranch house, corner of fence at east side of road, on township line; iron post stamped "167 B"	167.127
Cortina schoolhouse, 0.2 mile west of, southwest corner section 14, T. 14 N., R. 3 W., corner of fence; iron post stamped "211 B"	211.098

FORKS OF ROAD 1.2 MILES EAST OF CORTINA SCHOOLHOUSE, SOUTH TO COMMON CORNER TS. 13 AND 14, RS. 2 AND 3.

	Feet.
Arbuckle, 4.5 miles west of, 30 feet south of corner of Ts. 13 and 14 N., Rs. 2 and 3 W., corner of fence; iron post stamped "284 B"	284.174

SITES 30′ QUADRANGLE.

CROSSROADS 5 MILES WEST OF WILLOWS, ALONG ROAD SOUTH, TO CROSSROADS 5 MILES WEST OF NORMAN; THENCE TO NORMAN.

	Feet.
T. 19 N., R. 4 W., section 26, northwest corner of, on north and west side of road; iron post stamped "170 B"	170.026
T. 18 N., R. 4 W., northwest corner section 11, south and east of road; iron post stamped "168 B"	168.181
T. 18 N., R. 4 W., northwest corner section 24, 4 miles west of Norman, north and east side of road; iron post stamped "135 B"	135.149

POINT 3 MILES SOUTH BY 3 MILES WEST OF NORMAN, SOUTHWEST TO GOLDEN GATE SCHOOLHOUSE; THENCE SOUTH TO LURLINE.

	Feet.
Miles station, 3 miles north of, Campbell's house, 50 feet northeast of, 40 feet east of blacksmith shop, northeast corner of yard fence, at south side of road; iron post stamped "157 B"	157.041
Golden Gate schoolhouse, 1 mile south of, 400 feet south of Malloway ranch house, west side of road, 6 feet west of gate; iron post stamped "243 B"	243.080
Mills station, 120 feet east of water tank, northeast corner of platform, 5 feet south of track; iron post stamped "146 B"	146.157

FAIRVIEW STATION, SOUTH ALONG COUNTY ROAD, TO FRESHWATER.

Manor ranch, 0.2 mile southwest of ranch house, corner of fence at south side of county road; iron post stamped "157 B"	156.997

MANOR RANCH, SOUTH, TO STORAL RANCH.

Storal ranch house (West ranch), 600 feet northeast of, large gate, at west end of, north side of road; iron post stamped "183 B"	183.028

WILLOWS QUADRANGLE.

WILLOWS, NORTH ALONG RAILROAD, TO ORLAND.

Willows, 100 feet north of station, 75 feet west of track, north side of street, corner lot; iron post stamped "132 B"	130.896
Willows, Glenn County court-house steps; aluminum tablet stamped "138 B"	137.937
Willows, 700 feet north of station, 10 feet east of Southern Pacific track, 3 feet east of milepost 151 and section post 48–49, southwest corner brick warehouse; aluminum tablet stamped "134 B"	133.969
Lyman, 0.2 mile south of, opposite milepost 154, east side of county road, alongside right-of-way fence; iron post stamped "138 B"	137.098
Germantown, 0.7 mile south of, west side of county road, 900 feet south of crossroads, opposite milepost 157; iron post stamped "159 B"	158.226
Germantown, 2.5 miles north of, east side of county road, opposite milepost 160, at forks of road; iron post stamped "185 B"	184.001
Greenwood, at crossroads, west of station, west side of county road, opposite milepost 163; iron post stamped "230 B"	228.641
Orland station, 300 feet north of, 30 feet east of track, at road crossing; iron post stamped "256 B"	255.084
Orland, northwest corner of Bank of Orland; aluminum tablet stamped "256 B"	255.948

ORLAND, EASTERLY, TO ST. JOHNS.

Orland, 3 miles east of, 200 feet south of crossroads, east side of road at orchard; iron post stamped "217 B 37"	215.007

THREE MILES WEST OF ORLAND, SOUTH ALONG TOWNSHIP LINE, TO POINT 3 MILES EAST OF WILLOWS; THENCE TO WILLOWS.

Greenwood, 3 miles east of, northwest corner of fence at crossroads, 0.5 mile south of cemetery; iron post stamped "200 B 38"	199.472
T. 21 N., R. 3 W., southeast corner section 24, west side of road, 0.25 mile west of large lone tree, in field; iron post stamped "171 B 39"	169.318

	Feet.
T. 20 N., R. 2 W., southwest corner section 6, crossroads at Schlouse ranch house, at northeast fence corner; iron post stamped "152 B 40"	150.183
T. 20 N., R. 2 W., east of county road, 370 feet south of Central canal; iron post stamped "135 B"	132.616
Willows, 3.2 miles east of, crossroads, 100 feet north of ranch house, east side of road; iron post stamped "111 B"	109.941

CHICO, WEST TO ST. JOHNS; THENCE SOUTH TO JACINTO; THENCE WEST TO TOWNSHIP LINE.

St. John, 300 feet south of Stony Creek, 40 feet northeast of intersection of roads, in southwest corner of school yard; iron post stamped "143 B"	142.996
St. John, 2.4 miles south of, 1,200 feet southwest of white house, first turn in road to west, 12 feet northwest of fence corner; iron post stamped "134 B"	133.963
St. John, 5.1 miles south of, 150 feet north of bridge, 30 feet northeast of intersection of county roads and private road, 600 feet west of frame house, 2 feet northwest of fence corner; iron post stamped "122 B"	122.020
Jacinto, 0.1 mile north of, 500 feet north of red brick store, 20 feet south and 20 feet west of road, 6 feet west of signpost; iron post stamped "108 B"	107.986

JACINTO, SOUTH, TO GLENN.

Sidds Landing, at southeast corner of warehouse, 50 feet west of river, and 50 feet east of road; iron post stamped "106 B"	105.935
Glenn, 0.5 mile south of, 50 feet east of road, at front entrance to old schoolhouse, at south end of steps; iron post stamped "93 B"	92.987

VINA (FRUTO 30′) QUADRANGLE.

ST. JOHNS, NORTHWEST TO MCINTOSH RANCH; THENCE NORTH VIA SQUAW HILL, TO VINA.

Stony Creek station, 6 miles east of, 0.4 mile south of McIntosh's ranch house, intersection of private road with county road, 30 feet northwest of forks, 2 feet south of fence corner; iron post stamped "185 B"	184.996
Squaw Hill Ferry, 250 feet west of west landing, in fence corner; iron post stamped "196 B"	195.839

ORLAND, NORTH ALONG COUNTY ROAD, TO CORNING.

Orland, 2.6 miles north of, east side of road, 5 feet west of fence; iron post stamped "273 B"	271.486
Orland, 4 miles north of, west side of road, 300 feet north of dry creek, at foot of electric pole, 1,233; iron post stamped "274 B"	273.004
Orland, 6.6 miles north of, west side of road, 60 feet west of electric pole, 1,116; iron post stamped "286 B"	285.049
Orland, 10 miles north of, east side of road, in Maywood Colony, at electric pole, 964; iron post stamped "271 B"	269.972
Corning, 100 feet west of station, south side of street at northwest corner of warehouse; iron post stamped "273 B"	271.410

CORNING, EAST ALONG COUNTY ROAD, TO SQUALL HILL FERRY.

	Feet.
Corning, 3 miles east of, south side of road, at crossroads, 8 feet east of telephone pole; iron post stamped "222 B"	220.365

FROM CROSSROADS 3 MILES EAST OF CORNING, SOUTH ALONG COUNTY ROAD, TO CROSSROADS 3 MILES EAST OF ORLAND.[a]

Corning, 4 miles south by 3 miles east of, common corner secs. 5, 6, 7, and 8, T. 23 N., R. 2 W., at fence; iron post stamped "217 B"	216.028
Kirkwood, 2.5 miles southeast of, east side of road at fence corner; iron post stamped "215 B 35"	213.506
Malton, 2 miles east by 0.4 mile south of, 1 mile south of Jones ranch, west side of road at clump of fig trees; iron post stamped "220 B"	218.650

TEHAMA, SOUTH ALONG COUNTY ROAD, TO CROSSROADS 3 MILES EAST OF CORNING.

Tehama, 3.5 miles south of, 0.75 mile north of Thom Creek, east side of road, at foot of telegraph pole; iron post stamped "222 B"	220.661

CORNING, NORTH ALONG COUNTY ROAD, TO CROSSROADS 7 MILES NORTH OF CORNING.

Corning, 3 miles northwest of, at crossroads, west side of road, 5 feet north of telephone pole; iron post stamped "303 B"	303.496

FRUTO 30′ QUADRANGLE.

WILLOWS, WEST ALONG COUNTY ROAD 5.5 MILES; THENCE NORTH TO POINT 4.5 MILES WEST OF ORLAND; THENCE TO ORLAND.

Willows, 5 miles west of, south side of road near crossroads, opposite schoolhouse; iron post stamped "190 B"	189.868
T. 20 N., R. 4 W., sec. 23, Feeny place, west side of road near barn; iron post stamped "190 B"	189.751
T. 20 N., R. 3 W., northwest corner sec. 1, south of road; iron post stamped "204 B"	203.917
T. 21 N., R. 4 W., northwest corner sec. 24, west of road; iron post stamped "251 B"	250.866
T. 21 N., R. 4 W., northwest corner sec. 1, 600 feet east of Butte ranch house, north side of road, near fence corner; iron post stamped "281 B"	280.809

TEHAMA QUADRANGLE.

RED BLUFF, SOUTH ALONG COUNTY ROAD, TO CROSSROADS 7 MILES NORTH OF CORNING.[a]

Tehama, 5.5 miles west of, west side of road, Red Bluff at crossroads, 5 feet north of telephone pole; iron post stamped "308 B"	307.463

RED BLUFF, SOUTH ALONG COUNTY ROAD, TO CROSSROADS 7 MILES NORTH OF CORNING.[a]

Red Bluff, 6.5 miles south of, west side of road, 3 feet south of telephone pole; iron post stamped "311 B"	310.497
Red Bluff, 10.5 miles south of, west side of road, 4 feet north of telephone pole; iron post stamped "304 B"	303.664

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[a] The error distributed in this line is excessive.

TEHAMA, NORTH THROUGH CONE RANCH, TO RED BLUFF.

	Feet.
Tehama, 4 miles northeast of, 50 feet south of draw in small bunch of oaks, east side of county road, through Cone ranch; iron post stamped "233 B"	233.489
Antelope Creek, 40 feet north of bridge, east side of road; iron post stamped "234 B"	234.067
Cone estate, 0.25 mile north of adobe ranch house, west side of road, south side of Antelope Creek at bridge; iron post stamped "246 B"	246.129
Cone estate, Antelope ranch headquarters, beside walk in front of residence, east side of road; iron post stamped "271 B"	270.764

MILL CREEK HIGHWAY BRIDGE, EAST 4 MILES UP MILL CREEK; THENCE NORTH TO DAY CREEK; THENCE WEST TO ROAD FORK 1 MILE NORTH OF ANTELOPE RANCH.

T. 26 N., R. 1 W., sec. 31, southeast corner, north of Mill Creek, 10 feet north of road; iron post stamped "471 B"	471.259

WILD CAT GULCH, EASTWARD, TO T. 26 N., R. 1 W.

Wild Cat Creek, 2 miles east of, north side of road, in highest point of lava bowlder; aluminum tablet stamped "1040 B"	1,040.359

DRY CREEK, NORTHWEST AND WESTWARD ALONG PRIVATE ROADS AT BASE OF FOOTHILLS, TO RED BLUFF.

Dry Creek sheep camp, 4 miles north of, 350 feet west of west end of stone fence, 4 feet east of gatepost; iron post stamped "301 B"	300.865

POINT 6 MILES EAST OF RED BLUFF, EAST ALONG THE RED BLUFF AND LYONSVILLE ROAD, TO MUD SPRINGS.

Red Bluff, 6 miles east of, at forks of road to Tuscan Springs, near signpost; iron post stamped "307 B 1903"	306.629
Mud Springs, 0.25 mile west of, 15 feet south of road, in sec. 6, T. 27 N., R. 1 W., in lava bowlder, 6 by 4 by 2 feet; aluminum tablet stamped "1061 B"	1,061.406

MILL CREEK, SOUTH TO TOOMES CREEK; THENCE SOUTHWEST TO MILEPOST 207.

Lone Pine camp, Toomes Creek sheep camp, 200 feet west of ranch house, 4 feet east of telephone pole; iron post stamped "358 B"	358.180

IRON MOUNTAIN SPECIAL AND REDDING QUADRANGLES.

SHASTA COUNTY.

The elevations in the following list are based on an aluminum tablet set in first angle of wall on north side of east entrance to the court-house in Redding, about 3 feet above ground. The height of this bench mark was accepted as 589.658 feet, being determined by the precise-level line run by Mr. C. H. Semper in 1902, between Benicia, Cal., and Portland, Oreg. For additional elevations refer to precise leveling (p. 26).

The leveling on Redding quadrangle was done mostly in 1900 by Mr. L. A. Whereat, levelman, under the direction of Messrs. R. H.

McKee and A. B. Searle, topographers. The leveling on the Iron Mountain Special quadrangle is part of that on the Redding quadrangle, and was done by Mr. A. B. Searle in 1903. The latest work is a line from Redding via Shasta to Girvan, run in 1905 by Mr. G. C. Jacobs.

The standard bench marks set in 1900 are stamped with the letter "R" in addition to figures of elevation, mostly 2 feet too great; those set in 1903 and 1905 are stamped "B" with correct figures.

REDDING QUADRANGLE.

REDDING, VIA FURNACEVILLE, TO WARD'S RANCH ON REED'S TOLL ROAD.

	Feet.
Loomis Corners, west side of Leighton's house, 2 feet south of northeast corner of fence; iron post stamped "550 R"	547.964
Rocky Plains, near center of, 2 miles southwest of Ben Jenkins's house, 15 feet south of road; iron post stamped "1109 R"	1,106.749
Ward's field, 2 feet east and 8 feet south of fence around, south side of Reed's (Redding-Furnaceville) toll road and 12 feet west of fork of private road leading via Eiler's to Oak Run road; iron post stamped "1279 R"	1,276.685

ENTERPRISE, VIA PALOCEDRO AND BELLAVISTA, TO FRAZIER CORNERS.

Pacheco schoolhouse, 20 feet east of road, 2 feet south of southwest corner; iron post stamped "449 R"	446.953
Bellavista, 15 feet north of county road as traveled, 2 feet southwest of southeast corner of fence around superintendent's house; iron post stamped "537 R"	535.036

PALOCEDRO, VIA MILLVILLE AND PAWNEE, TO WARD'S RANCH AND CLOVER CREEK FALLS ON FURNACEVILLE ROAD.

Millville schoolhouse, 2 feet south of southwest corner of; iron post stamped "513 R"	510.942
Frank Joseph's house, 540 feet northeast of, 6 feet southeast of tamarack road, 1.5 feet from northwest fence corner of the Tom Webb place on the continuation of division line between the Webb and Joseph farms; iron post stamped "977 R"	974.996

MILLVILLE, VIA SHINGLETOWN CUTOFF ROAD, TO BEAR CREEK CROSSING.

George Darr's house, 190 feet east of gate, 2 feet north of fence, south side of road, on top of grade going down to Bear Creek; iron post stamped "806 R"	803.633

REDDING, VIA SHASTA, TO KESWICK.

Shasta, 50 feet northwest of west corner of Empire Hotel, 4 feet south of corner of corral, on northeast side of the main street, and on northwest side of street to Keswick; iron post stamped "1049 R"	1,046.886
Keswick schoolhouse, 6 feet south of first angle of west face; iron post stamped "778 R"	775.897

SHASTA, SOUTH ALONG ROAD TO CENTERVILLE (LARKIN); THENCE EAST TO GIRVAN.

	Feet.
Shasta, 2.7 miles south of, on ledge of rock facing south, west side of road, 150 feet south of old shed; aluminum tablet stamped "930 B 05"	929.959
Centerville (Larkin), west side of road, opposite Centerville store; iron post stamped "876 B"	876.459
Centerville, 2.9 miles east of, 80 feet south of road, 300 feet west of house at junction of roads from Redding and Girvan to Centerville, on ledge of sandstone; aluminum tablet stamped "562 B 05"	562.338

FRAZIERS CORNERS, VIA BEAR VALLEY, COPPER CITY, MADISON'S AND KELLEY'S RANCH, TO BAGLEY FLAT (SINGLE SPUR LINE).

Houston ranch, 1.6 miles northwest of, on Stillwater road 15 feet south of fork with and 5 feet east of Copper City road, 500 feet south of forks with road to Bass's; iron post stamped "710 R"	707.791
Bear Valley, 0.15 mile southwest of stage station, 180 feet northeast of junction with Bellavista road, 18 feet southeast of road, 2 feet northwest of fence, on top of hill; iron post stamped "945 R"	942.672
Copper City, 25 feet south of schoolhouse, at southeast corner of lot as at present defined by fence; iron post stamped "806 R"	803.877
Squaw Creek, near east side line of T. 34 N., R. 2 W., 300 feet above first crossing, 1.87 miles north of Madison's house, 6 feet east of trail; iron post stamped "1047 R"	1,044.357
T. 35 N., R. 2 W., 1.39 miles north of Kelly's house, near east range line, 10 feet west of trail on saddle; iron post stamped "1536 R"	1,533.719
Bagley Flat, 135 feet southwest of cabin, 85 feet southwest of head of spring; iron post stamped "2730 R"	2,727.880

POINT ON SOUTHERN PACIFIC RAILROAD, UP MIDDLE SALT CREEK.

T. 36 N., R. 4 W., 3.5 feet west of southeast corner of sec. 30, on line between Ts. 35 and 36 N., R. 4 W., Mount Diablo meridian; iron post stamped "1182 R"	1,180.038

BENCH MARKS BASED UPON M'CLOUD RIVER DITCH LEVELS, CORRECTED FROM DATA FURNISHED BY J. R. ROGERS, ENGINEER IN CHARGE.

T. 34 N., R. 4 W., northwest corner of sec. 23, 5 feet southeast of northwest corner of "McCloud River," U. S. Fish Reservation, 30 feet west of county road; iron post stamped "856 R"	853.786
T. 36 N., R. 3 W., south edge of sec. 31, on west bank of McCloud River, near head of Rogers ditch line, and 100 feet west of ditch station 71+50, 146 feet west of 10-inch forked live oak tree; iron post stamped "1060 R"	1,057.616

IRON MOUNTAIN SPECIAL (REDDING 30′) QUADRANGLE.

KENNETH, WEST ALONG ROAD TO BALAKLALA; THENCE ALONG TRAIL, VIA SPREAD EAGLE MINE AND SADDLE OF COPLEY RIDGE (0.5 MILE EAST OF SUGARLOAF MINE), TO COPLEY.

Balaklala Mining Company's office, 20 feet north of north end of, 20 feet south of road, at base of stone wall; iron post stamped "2286 B"	2,285.922

	Feet.
Spread Eagle mine, 0.5 mile northeast of, 5 feet west of trail at point of ridge; iron post stamped "2757 B"	2,756.924
Forks of Copley–Sugar Loaf and Minnesota–Sheep Springs trail, 10 feet east of, in saddle; iron post stamped "2560 B"	2,560.138

BORALMA, ALONG ROAD, TO TUNNEL NO. 11 OF TRINITY COPPER COMPANY.

Tunnel No. 11, Trinity Copper Company, 2 feet southwest of mouth; iron post stamped "1636 B"	1,636.086

BIG BAR, EUREKA, HOOPA, KORBEL, AND WEAVERVILLE QUADRANGLES.

HUMBOLDT, SHASTA, AND TRINITY COUNTIES.

The elevations in the following list are based on an aluminum tablet set about 3 feet above ground in first angle of wall on north side of east entrance to the court-house in Readding, accepted as being 589.658 feet above mean tide. In October, 1905, levels were run west and north over road and trail to vicinity of China Flat, work being abandoned in January, 1906. The leveling was done by Mr. George C. Jacobs, levelman, with a prism level and two rodmen with self-reading yard rods. In August, 1906, work was continued in the same manner with prism level by Mr. L. F. Biggs, levelman, northward to Hoopa Valley and westward to Eureka. At this point the Coast and Geodetic Survey bench mark on the warehouse wharf was sought but was not recovered. City bench marks Nos. 2 and 3 were checked on, their city value being 14.925 and 35.113 feet, respectively. Their datum plane as established by the United States Army engineers was accepted as 2.480 feet lower than mean tide, making their accepted elevations 12.445 and 32.633 feet, respectively.

The error of closure was found to be excessive, and although the elevations in this list are adjusted they must be regarded as preliminary only.

The lines of levels run by Mr. Jacobs and Mr. Biggs on the Shasta–Eureka line were checked roughly by second running by flying levels in opposite direction by Mr. Biggs.

WEAVERVILLE QUADRANGLE.

SHASTA, NORTHWEST ALONG ROAD VIA STELLA AND LOWDEN, TO WEAVERVILLE.

	Feet.
Shasta, 2 miles northwest of, 30 feet northeast of Camden turnpike at Shasta divide, and 75 feet east of telephone pole; iron post stamped "1428 B 1905"	1,428.345
Stella post-office; center of bridge over Whiskey Creek	1,065.6
Stella, south side of road, opposite hotel; iron post stamped "1091 B 1905"	1,091.031
Oak Bottom, 0.2 mile northwest of, northeast side of Camden turnpike, 6 telephone poles east of Shasta 8 milepost, on ledge of rock facing east; aluminum tablet stamped "1191 B 1905"	1,190.916

	Feet.
Tower House, 0.7 mile southeast of, north side of Camden turnpike, 630 feet northwest of Tower House 1 milepost; aluminum tablet stamped "1318 B 1905"	1,317.641
Tower House, 3.5 miles west of, south side of Shasta and Weaverville turnpike, on large bowlder opposite Endicott ranch house; aluminum tablet stamped "1750 B 1905"	1,750.025
Buckhorn station, 4.4 miles east of, south side of road and east end of cut at summit; iron post stamped "3252 B 1905"	3,260.917
Buckhorn, 2.4 miles east of station, east side of road, at culvert, on large bowlder; aluminum tablet stamped "2754 B 1905"	2,763.541
Buckhorn, 1.2 miles northwest of station, north side of road, on large bowlder; aluminum tablet stamped "2374 B 1905"	2,382.974
Lowden, 1.5 miles southeast of, north side of road, in rock; aluminum tablet stamped "2093 B 1905"	2,102.466
Lowden, west side of road in front of hotel; iron post stamped "1754 B 1905"	1,763.500
Lowden, 3.2 miles northwest of, north side of road, 320 feet southeast of Weaverville milepost 6, on rock; aluminum tablet stamped "2710 B 1905"	2,722.304
Weaverville, 2.9 miles south of, 375 feet north of junction of roads from Lowden and Douglas, east side of road on ledge of rock; aluminum tablet stamped "1816 B 1905"	1,828.647
Weaverville, southeast corner of court-house, in pavement; aluminum tablet stamped "2034 B 1905"	2,046.869

WEAVERVILLE, ALONG ROAD VIA JUNCTION, TO HELENA.

Weaverville, 2.8 miles west of, 0.5 mile east of summit, north side of road, on rock; aluminum tablet stamped "2738 B 1905"	2,750.674

BIG BAR QUADRANGLE.

ALONG HIGHWAY, VIA JUNCTION CITY, TO HELENA.

Junction City, 3.9 miles east of, 0.9 mile west of La Grange mine, southwest side of road, in top of stone monument, Mount Diablo meridian; copper plate stamped "2218 B"	2,230.907
Junction City, northwest side of road, 200 feet west of gravel bluff, 200 feet south of church, on large white bowlder; aluminum tablet stamped "1478 B 1905"	1,491.026
Junction City, 2.7 miles northwest of, north side of road, 300 feet west of where North Mountain Power Company's pipe line crosses road, on ledge of rock; aluminum tablet stamped "1747 B 1905"	1,760.070
Helena, 2.3 miles east of, southeast side of road, northwest bank of Trinity River, on large bowlder; aluminum tablet stamped "1410 B 1905"	1,422.594
Helena post-office, northeast side of road, 4 feet from south corner of brick store; iron post stamped "1391 B 1905"	1,403.506

HELENA, ALONG TRAIL DOWN NORTH SIDE OF TRINITY RIVER, TO LUCCOCKS BAR; THENCE ON SOUTH SIDE TO DON JUAN POINT; THENCE ON NORTH SIDE TO CEDAR FLAT.

Helena, 3 miles west of, south side of trail, east side of brook, top of rock in Cut Throat Gulch; aluminum tablet stamped "1637 B 1905"	1,649.862

	Feet.
Big Bar, 3.5 miles east of, north side of Big Flat, 80 feet north of trail, 20 feet northwest of power pole, on rock; aluminum tablet stamped "1304 B 1905"	1,313.460
Big Bar, 0.7 mile east of, opposite Big Bar Hotel, 450 feet north of suspension bridge, 30 feet north of trail, east side of gulch, 250 feet east of house, top of rock; aluminum tablet stamped "1238 B 1905"	1,247.585
Big Bar, 2.1 miles west of, north side of trail, at base of rock cliff facing southeast; aluminum tablet stamped "1398 B 1905"	1,408.076
Taylor Flat, 1.3 miles east of, north side of trail, 850 feet east of rock cliff, top of bowlder; aluminum tablet stamped "1229 B 1905"	1,239.125
Taylor Flat, 1.6 miles west of, 1,500 feet west of Canadian Bar, 80 feet south of trail, on rock; aluminum tablet stamped "1263 B 1905"	1,272.801
Cedar Flat, 5.4 miles east of, north side of trail, 625 feet east of Vance Creek, on rock; aluminum tablet stamped "1183 B 1905"	1,193.425
Cedar Flat, 1.9 miles east of, 675 feet west of suspension bridge over Trinity River, top of rock; aluminum tablet stamped "1003 B 1905"	1,002.262
Cedar Flat, 1.3 miles west of, 400 feet west of landslide, 40 feet north of trail, on rock; aluminum tablet stamped "1240 B 1905"	1,249.460

KORBEL QUADRANGLE.

SOUTH BANK, TO HAWKINS BAR; THENCE VIA CAMPBELLS BRIDGE, TO CHINA FLAT.

Burnt ranch, 500 feet west of house, 250 feet south of cemetery, 300 feet southeast of trail, on large bowlder; aluminum tablet stamped "1591 B 1905"	1,601.622
Gray, 175 feet north of trail, 500 feet northwest of house, on large bowlder; aluminum tablet stamped "777 B 1905"	787.516
Hawkins Bar, 175 feet northwest of barn, 15 feet north of trail, on rock; aluminum tablet stamped "859 B 1905"	869.491
Donahue ranch house, 2.7 miles southeast of, 60 feet west of trail, edge of river, 100 feet west of creek, top of rock; aluminum tablet stamped "519 B 1905"	528.898
Donahue ranch house, 0.6 mile northwest of, 25 feet northwest of trail, 50 feet northwest of log cabin, at junction of South Fork and Trinity River, on rock; aluminum tablet stamped "543 B 1905"	553.385
China Flat, 2.4 miles south of, west side of road, top of rock; aluminum tablet stamped "646 B 1906"	645.195
China Flat, 160 feet north of hotel, 70 feet northeast of road to Hoopa, top of rock; aluminum tablet stamped "451 B 1906"	461.149
China Flat, 2.8 miles north of, south side of road, first summit, large rock; aluminum tablet stamped "BB 1906 20"	644.210

CHINA FLAT, ALONG ROAD VIA ACORN, TO KORBEL.

China Flat, 2.8 miles west of, 50 feet east of road, 25 feet south of Little Brannen Creek, 200 feet northeast of Koby ranch house, top of rock; aluminum tablet stamped "1459 B 1906"	1,469.422
Haas ranch house, 1.5 miles east of, 15 feet south of road at summit, top of rock; aluminum tablet stamped "3109 B 1906"	3,118.616
Haas ranch house, 225 feet northeast of, 35 feet northwest of road, on rock; aluminum tablet stamped "2352 B 1906"	2,362.617

	Feet.
Haas ranch house, 3 miles southwest of, 150 feet west of Redwood summit, south side road, in slate; aluminum tablet stamped "BB 3701 1906–13"	3,714.927
Redwood summit, 3 miles southwest of, 2.2 miles east of Berry's ranch house, west edge of road; aluminum tablet stamped "2517 B 1906"	2,530.941
Berry's ranch house, 100 feet southeast of, west face of rock; aluminum tablet stamped "B 1906"	1,037.563
Berry's ranch house, 3.4 miles northwest of, at junction of road from Baer ranch and China Flat, 4 feet south of telephone pole, on rock; aluminum tablet	2,423.727
Solano, 0.6 mile east of, 225 feet north of summit, 5 feet east of road, on rock; aluminum tablet stamped "B 1906"	3,079.729
Solano, 1.5 miles west of, 20 feet northeast of road, on ledge of sandstone; aluminum tablet stamped "B 1906"	2,483.452
Solano, 4.1 miles southwest of, 30 feet northwest of road, 1,500 feet southwest of mile tree 27, on rock; aluminum tablet stamped "1949 B 1906"	1,962.590
Korbel, 100 feet south of station, west side of large stone ledge; aluminum tablet stamped "BB 15 1906 1902"	115.673

EUREKA QUADRANGLE.

KORBEL, ALONG ARCATA AND MAD RIVER RAILROAD, TO ARCATA.

Blue Lake station, in front of; top of rail	87.8
Korbel, 1.7 miles southwest of, 0.6 mile west of Blue Lake, north side of railroad, large bowlder; aluminum tablet stamped "BB 16 1906 72"	85.726
Korbel, 6.2 miles west of, 3.6 miles east of Arcata, 300 feet south of Webster ranch house, south side of track, large bowlder; aluminum tablet stamped "33.17 1906 58"	72.202
Arcata, southeast corner of Eighth and H streets, northwest corner of brick building 25 by 100 feet; aluminum tablet stamped "BB 18 1906 27"	27.109

ARCATA, ALONG EUREKA AND OREGON RAILROAD, TO EUREKA.

Bayside station, in front of; top of east rail	7.793
Northeast corner of Pacific Steamship Company's warehouse; nail in floor	8.273
Eureka, at intersection of Third and E streets, city bench mark No. 2	12.445
Eureka City Hall, east approach to, north side of steps, in top of granite post; aluminum tablet stamped "BB 1906–19 31"	30.934
Eureka, at intersection of Third and H streets, city bench mark No. 3	32.633
Eureka, north approach to court-house, west side of steps, granite post; aluminum tablet stamped "BB 1906–20–44"	44.059

HOOPA QUADRANGLE.

NEAR CHINA FLAT, ALONG ROAD, TO HOOPA.

China Flat, 6.3 miles north of, west edge of road, country rock; aluminum tablet stamped "BB 21, 1906"	1,354.915
Hoopa, 2.4 miles south of, 1,300 feet south of mile tree 63, 1,700 feet north of bridge, west edge of road, bowlder; aluminum tablet stamped "BB 22 1906"	386.042

	Feet.
Hoopa, 1,000 feet north of Bigard's store, right edge of steps to United States Indian agent's office; aluminum tablet stamped "BB 352 23 1906"	351.270

HOOPA, NORTH ALONG ROAD AND TRAIL 7.5 MILES (SINGLE SPUR LINE).

Hoopa, 3.2 miles north of, 150 feet south of Soctish Creek, west edge of road, country rock; aluminum tablet stamped "BB 24 1906"	308.482
Hoopa, 7.5 miles north of, west edge of trail, slate rock; aluminum tablet stamped "BB 25 1906"	1,006.208

HOOPA, SOUTHWEST ALONG TRAIL AND ROAD, TO FORKS OF ROAD 3.4 MILES NORTHWEST OF BERRY RANCH HOUSE.

Hoopa, 3.8 miles west of, 20 feet west of Fourmile Creek, large bowlder; aluminum tablet stamped "B 1716 1906"	1,715.199
Hoopa, 6 miles west of, 10 feet south of trail, country bowlder; aluminum tablet stamped "B 27 2899 1906"	2,900.323
Baer's ranch, 4.5 miles east of, north edge of trail, highest point, country rock; aluminum tablet stamped "B 28 1906 3495"	3,494.856

KORBEL QUADRANGLE.

AT BAERS RANCH.

Baer's ranch, 0.8 mile east of, 20 feet south of trail, very large bowlder known as "14-mile rock;" aluminum tablet stamped "B 29 1359 1906"	1,358.118
Baer's ranch house, 1,000 feet southwest of, southwest corner of bridge, top of pier; aluminum tablet stamped "B 30 1906 732"	731.773

PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

The publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists can be had on application.

Most of the above publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained, free of charge (except classes 2, 7, and 8), on application.
2. A certain number are delivered to Senators and Representatives in Congress for distribution.
3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost.
4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they can be consulted by those interested.

BULLETINS CONTAINING ELEVATIONS.

72. Altitudes between Lake Superior and Rocky Mountains, by Warren Upham. 1891. 229 pp.

169. Altitudes in Alaska, by Henry Gannett. 1900. 13 pp.

175. Triangulation and spirit leveling in Indian Territory, by C. H. Fitch. 1900. 141 pp., 1 pl.

185. Results of spirit leveling, fiscal year 1900–1901, by H. M. Wilson, J. H. Renshawe, E. M. Douglas, and R. U. Goode. 1901. 219 pp.

274. A dictionary of altitudes in the United States (fourth edition), compiled by Henry Gannett. 1906. 1,072 pp.

281. Results of spirit leveling in the State of New York for the years 1896 to 1905, inclusive, by S. S. Gannett and D. H. Baldwin. 1906. 112 pp.

288. Results of spirit leveling in Pennsylvania for the years 1899 to 1905, inclusive, by S. S. Gannett and D. H. Baldwin. 1906. 62 pp.

Results of spirit leveling by the United States Geological Survey also appear in the appendices to the 18th, 19th, 20th, and 21st annual reports of the Director.

Address communications to the Director.

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

BULLETIN 343

BINDERS FOR COAL BRIQUETS

INVESTIGATIONS MADE AT THE FUEL-TESTING PLANT ST. LOUIS, MO.

BY

JAMES E. MILLS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

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BINDERS FOR COAL BRIQUETS:

INVESTIGATIONS MADE AT THE FUEL-TESTING PLANT, ST. LOUIS, MO.[a]

By James E. Mills.

INTRODUCTION.

THE COMMERCIAL PROBLEM.

Coal, in the process of mining, transportation, and handling and on exposure to the weather, is subject to more or less disintegration. This disintegrated coal is usually called "slack" and amounts often to a considerable percentage of the lump coal produced in the mines. If this slack coal is wasted the loss so occasioned ranges from 5 to 50 per cent, or even more, of the total coal mined. It is therefore clear that the utilization of this waste slack coal becomes a serious economic consideration.

When the coal is suitable for the production of coke, the utilization of the slack presents no difficulty, as it is in demand for that purpose. If the coal does not produce good coke, but cakes rather readily, the slack can be used for boiler purposes, as it fuses together more or less quickly, and burns on the furnace grate without great loss. Coal that cakes less readily can be burned on grates of special construction. When so used it is more troublesome to handle, and the waste is greater than when lump coal is used. Consequently the price of much of the slack coal for fuel purposes ranges considerably lower than that of the lump coal from the same mine.

The full value of this slack coal as fuel can be realized by first forming the coal into a coherent mass or briquet, such briquets, when of good quality, being equal to or of greater value than the original lump coal from which the slack was derived. The object of the investigations herein reported was to determine as far as possible to what extent the manufacture of briquets from slack coal may succeed commercially under the conditions existing in the United States.

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[a] The writer undertook the work herein reported, in 1905, at the fuel-testing plant of the United States Geological Survey; under the direction of Dr. Joseph Hyde Pratt, of the University of North Carolina, to whom he is greatly indebted for advice and suggestions, given not alone at the beginning but throughout the progress of the work. Acknowledgment is also due for suggestions given by Mr. A. A. Steel, of the University of Arkansas, and for the assistance of many individuals and corporations who have answered inquiries and furnished samples as desired. In compiling this report and in laboratory work free use has been made of all available information thus acquired.

The problem of briquetting is not always that of how to make the best possible briquet, for the slack at hand may be of inferior quality and the best possible binding material may be too expensive for the conditions prevailing in that particular locality. The problem is always to produce at a profit a briquet of satisfactory grade for the use intended. This problem will be made clearer by a brief summary of the available binders, followed by a preliminary discussion of the characteristics of a good briquet.

THE KIND OF BINDER.

Definite answer to the question "What is the best binder to use in making briquets?" depends, as repeatedly emphasized in this paper, on the locality, on the character of the coal, and on the purpose for which the briquets are intended. For purposes of a brief comparison consideration is given to the binders available for a coal which is fairly easy to briquet and which cakes rather readily. A few coals will briquet with somewhat less and others require greater percentages of binder, but an endeavor has been made in the following summary to strike a reasonable average.

The experiments herein reported show that, in general, for plants situated where it can be obtained, the cheapest binder will prove to be the heavy residuum from petroleum, often known to the trade as asphalt. Four per cent of this binder being sufficient, its cost ranges from 45 to 60 cents per ton of briquets produced. This binder is particularly available in California, Texas, and adjacent territory.

Second in order of importance comes water-gas tar pitch. Five to six per cent usually proving sufficient, the cost of this binder ranges from 50 to 60 cents per ton of briquets produced. As water-gas pitch is also derived from petroleum, it will be available more particularly in oil-producing regions.

Third in order of importance is coal-tar pitch. Being derived from coal, this binder is very widely available. From 6.5 to 8 per cent will usually be required, and the cost ranges from 65 to 90 cents per ton of briquets produced.

Of local importance, where the price permits, are natural asphalts and tars derived from wood distillation. The price of each of these binders varies greatly with the locality, but there are doubtless places where they could compete with the binders above mentioned. Wax tailings could be used with an easily caking coal.

Pitch made from producer-gas tar is not yet on the market, but it will produce excellent briquets, with a lower percentage of binder than other coal-tar pitches. It will doubtless be available in the future.

Briquets excellent in all respects except that they are not waterproof can be made by using 1 per cent of starch as a binder, the cost of which is 20 cents per ton of briquets produced. Extra care is necessary in drying and handling these briquets, and this adds to their cost.

The waste sulphite liquor from paper mills also produces excellent briquets except that they are not waterproof. At present it is a troublesome waste product dissolved in much water. Its utilization for this purpose will bear further investigation.

Of inorganic binders, magnesia might be utilized, as its probable cost would not exceed 22 to 30 cents per ton of briquets produced. Other inorganic binders, while available as regards price, would not make first-class briquets.

The briquetting of lignite coal offers a peculiarly difficult problem. If the lignite cakes in the fire, asphaltic residues from petroleum or water-gas tar pitch may be used as binder, larger percentages being required than for ordinary coals. The most promising binders for lignites that do not cake are starch, sulphite liquor, and magnesia. Lignites may be briquetted without binder if they are to be burned on grates specially constructed to overcome the tendency to fall to pieces in the fire.

Attention is called to the suggested method of deciding as to the value of coal-tar pitch for briquetting purposes. The method is likewise applicable to asphalts and petroleum residues generally: (1) The pitch or tar is distilled and all oils coming off below 270° C. are rejected as being of no value; (2) the flowing point of the portion to be used in briquetting is determined (this should generally not be less than 70° C.); (3) the pitch is extracted with carbon disulphide. The smaller the amount of residual carbon the more satisfactory is the pitch. The less readily the coal cakes the higher must be the flowing point of the pitch. If a pitch cracker is used, the pitch to work successfully on a hot summer's day must have a flowing point above 120° C. In the winter pitch with a flowing point of 100° C. may be used. All softer pitches and asphalts have to be melted and mixed in liquid form with the coal.

A pitch with a very high softening point, above 150° C., should be either thinned or superheated in the mixer. The efficient use of a binder depends very largely on the proper regulation of the conditions in the mixer. The presence of low-volatile compounds in the pitch to be used as a binder increases the smoke in burning; and also increases the tendency of the briquet to soften and crack open in advance of combustion, owing to the volatilization and escape of these compounds.

The main problem in briquetting is to find a suitable binding material at sufficiently low cost. When the difference in price between the slack coal and the first-class lump coal is $1, the cost of briquetting should not exceed this amount. Of this the binder must cost less than 60 cents per ton, as the cost of manufacture averages about 40 cents. To leave out of consideration the possible advantages in the use of briquetted coal over run-of-mine coal, due to the greater efficiency and smokelessness of briquets, it will probably not be necessary to pay any attention to binding materials costing $1.25 or more per ton of briquets produced.

CHARACTERISTICS OF GOOD BRIQUETS.

COHERENCE.

The briquet should be sufficiently coherent. In France briquets are tested for coherence as follows:[a]

> One hundred and ten pounds of briquets are divided into 100 pieces of 1.1 pounds each, which are placed in a cylinder 36.22 inches in diameter and 39.57 inches in length. This cylinder is divided into three compartments by diametrical partitions and revolves at a speed of 25 revolutions per minute. After being charged, it is revolved for two minutes, and the contents are thereupon sifted upon a screen perforated with holes 1.12 inches square. The proportion which does not pass through this screen indicates the degree of cohesive force, which, in the case of the French Admiralty tests, should reach 52 per cent, or if the fuel be intended for torpedo boat use, 58 per cent.

Briquets of any desired degree of coherence may be made by varying the amount of binding material used in the briquet and by varying the pressure. An increase of either the binder or the pressure, of course, represents an added cost in manufacture. Experiments made by M. Wèry, of Paris,[b] with a Biétrix machine may be taken as illustrative:

Effect on coherence of varying pressure and amount of binder.

Pressure in kilograms per square centimeter.	Pressure in pounds per square inch.	Per cent of pitch used.	Per cent of cohesion obtained.
130	1,844	6	25
190	2,695	6	46
270	3,831	6	61
130	1,844	7	52
190	2,695	7	70
250	3,547	7	74

Ordinarily briquets may be considered sufficiently coherent when the loss occasioned by dust and breakage involved in their use does not exceed 5 per cent. Both manufacturers and consumers should recognize the desirability of adapting the briquet to the use intended.

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[a] Briquets as fuel: Special Consular Report, vol. 26, p. 54.

[b] Idem., p. 50.

HARDNESS AND TOUGHNESS.

The briquet should be sufficiently hard; but if too hard it is likewise brittle, and therefore less coherent when subjected to rough handling. It is usually advantageous, therefore, to make the briquet of the minimum hardness that will suffice for the purpose in view. A briquet can be made harder by using a binder with a higher softening (melting) point. Consequently, if pitch is used, the most brittle pitch makes the hardest briquet. Moreover, a larger percentage of the more brittle pitch is usually required.

The requirement of the French Admiralty is that the briquet should not soften at 60° C. (140° F.). Ordinarily it is sufficient that the briquet shall not soften on the hottest day, and shall behave satisfactorily on burning.

DENSITY.

It is sometimes specified that the briquet should have a density of not less than 1.19. Perhaps a better standard would require the briquet to about equal in density the lump coal from which the slack was derived, thus ranging from 1.1 to 1.4. The density is increased by pressure.

SIZE AND SHAPE.

The convenience of a briquet for a given purpose, and hence the extent of its use, will depend largely on the size and shape. Attention is therefore called to the following points:

Heavy rectangular blocks allow a large output for the investment and are consequently cheaper to manufacture. They are convenient for storage. The French naval estimates show that 10 per cent more in weight of briquets can be stored in a given space than of lump coal, and the British Admiralty reports show a gain of as high as 20 per cent. Large rectangular briquets have the disadvantage of large smooth surfaces and are usually broken up when fed into furnaces, as this appears to promote combustion. To facilitate the breaking they are pressed with grooves or perforations. This gives better air circulation but decreases the output and the possibility of storage by just so much.

Prismatic shapes with rounded edges are most popular abroad. Either these or ovoid shapes of less than 2 pounds weight are preferred for domestic use. The rounded edges cause much less dust and breakage on handling and insure good air circulation and thorough combustion, but are wasteful in space and make the briquet somewhat harder to ignite.

The output of hollow, cylindrical, polygonal, and ball-shaped briquets abroad is small, the other shapes having proved more generally preferable.

WEATHERING.

The briquet should stand long exposure to the weather with but little deterioration. A dense briquet will stand the weather better than a porous one. In the process of manufacture briquets are liable to crack if they lack the proper proportion of binder, or if the binder and coal particles have been improperly mixed, or if the briquets are pressed too wet, or are insufficiently pressed. If the coal is finely ground, the briquet assumes a more dense and polished surface and is then more resistant to the weather. Cracks, however produced, allow the entrance of moisture and cause a rapid deterioration of the briquet on exposure to the weather. Lignite briquets, owing probably to the tendency of the lignite to absorb water and also to the more porous structure of the briquet, do not stand long exposure to the weather as successfully as other briquets.

The binder used must be insoluble in water. The great obstacle to the successful use of starch, molasses, and sulphite-liquor residues as binders is their solubility, the cost of rendering the briquet waterproof being usually prohibitive. It is deserving of serious consideration whether or not in certain dry portions of the West, where fuel is scarce, the waterproofing of the briquet could not be dispensed with altogether during the dry season, and to a considerable extent during the rainy season by keeping the briquets under cover.

With pitches, tars, etc., a slightly increased percentage of binder is necessary in briquets that are to stand long exposure to the weather. Further details are given under the discussion of the various binders.

ABSORPTION.

The briquet should not absorb more than about 3 per cent of moisture. The amount of moisture absorbed is increased when either the slack itself or the briquet is porous, or when the binder used has a tendency to attract moisture.

BURNING QUALITIES.

Readiness of ignition.—The ease with which a briquet will ignite depends largely on the slack used, but can be regulated to some extent. Large briquets ignite less readily than small ones. Sharp edges are an aid to ignition, though this advantage is not so great as to overcome the general preference for the prismatic and egg-shaped briquets. Briquets made from fine slack ignite less readily than those from coarser slack. A dense briquet is also more difficult to ignite. The use of an inorganic substance, such as clay or magnesia, as a binder, or as a constituent of the binder, tends to make the briquet ignite less readily. Increase of inorganic material—that is, ash—in the slack coal used produces the same result.

Kind of flame.—The briquet should burn with a clear, intense flame, and without odor or smoke. The burning of the briquet and the flame produced, as well as the smoke given off, will depend largely on the quality of the slack coal used and on the completeness of the combustion. The completeness of combustion can be regulated to some extent in the manufacture of briquets by making them of a shape to insure a good air circulation and by the choice of a suitable binder. So far as the choice of a binder for this purpose is concerned, the principle involved may be summed up in the statement that the smoke does not depend on the total amount of volatile matter in the briquet, but only on that part of the volatile matter which escapes before it is heated to the kindling temperature. In other words, the binder should not volatilize before the temperature is sufficiently high to insure complete combustion of the gases formed. In general terms, therefore, a binder adds smoke in proportion to the amount of low-boiling constituents (oils, etc.) that it contains.

Inorganic binders, of course, produce no smoke. Such organic binders as starch, molasses, or sulphite-liquor residues likewise do not volatilize until decomposed, and hence do not smoke, or smoke but little. Pitches, tars, and petroleum residues, when used as binders, volatilize, and will cause smoke and possibly odor if the gases formed are not completely burned. But it is quite possible to regulate the conditions, even when using these binders, in such a way that the briquets will produce less smoke than the lump coal from the screenings of which the briquet is made. This is due to the regular shape of the briquet, which allows a better-regulated air supply, enabling more complete combustion to take place. This reduction of the smoke nuisance is one of the advantages to be derived from the use of briquets.

Retention of shape.—The quality of retaining its shape in the fire is very important and depends on the properties of both the coal and the binder used in making the briquet. This point is discussed more fully in connection with the various coals and binders examined. The principle involved is very simple. The binder must hold the coal particles together until they are sufficiently softened to cohere. The temperature at which different coals soften or cake together varies greatly. Some bituminous coals cake readily at a low temperature, others less so. Semianthracite coals follow next in order, and then anthracite coals, some of the very hard anthracite coals with only a small amount of volatile matter showing little tendency to cake. Lignites as a class do not cake readily. Some, however, as those from Oklahoma or New Mexico, will cake sufficiently at a rather high temperature to hold themselves together. Others, as some California, Texas, or North Dakota lignites, show practically no tendency to soften or cake at any temperature. With such lignites it is extremely difficult to make a briquet that will retain its shape in the fire. Briquets satisfactory for domestic use, when properly managed, can be made from such lignites. These briquets might be used in a variety of manufacturing operations if a grate suitably adapted to the fire box is provided. For use in a locomotive they would be less suitable.

With a readily caking coal, a binder that volatilizes (boils) at a comparatively low temperature may be used. With coals that cake at higher temperatures a less volatile binder must be used to obtain a satisfactory result in the fire. With a lignite that does not cake, the only binder that will enable the briquet to retain its shape until completely consumed is an inorganic binder which does not volatilize at all—unless, indeed, sufficient binder is added to practically coke the briquet. With such lignites, organic binders that do not volatilize, such as starch, molasses (in the form of waste residues from the sugar factories), sulphite-liquor residues from the paper mills, etc., give results that are fairly satisfactory, the briquet retaining its shape until the binder is itself decomposed. As the inorganic binders add ash and the other nonvolatile binders mentioned are not waterproof, it would seem generally better, where commercially possible, to mix a coal that will not cake of itself with a sufficient quantity of caking coal. Then when a suitable binder is used the briquet will retain its coherence in the fire by the softening of the caking coal used. The relation between the caking of a coal and its constitution is not well understood.

Percentage of ash.—The amount of ash left when the briquet is burned is the sum of that contained in the slack and in the binder used. Organic binders, as a rule, contain a smaller percentage of ash than the slack coal, and therefore slightly decrease the total percentage of ash in the briquet. When inorganic binders are used the ash thus added is a decided disadvantage.

In some foreign countries only 6 per cent of ash is permitted under many of the contracts for briquets. When the ash content of the slack exceeds 6 per cent it is therefore quite common abroad to wash the slack coal before briquetting. This saves freight on an incombustible material, saves binder, and gives in every way a better and more concentrated fuel. In this country, where good coal is so much cheaper than abroad, it will probably not usually prove feasible to wash the slack coal.

EVAPORATION RESULTS.

Theoretically the heating value of a briquet is the sum of the heating values of the coal and of the binder; and it can not possibly exceed this amount. Organic binders usually equal or exceed in heating value, weight for weight, the slack coal used. Usually, therefore, they increase the total heat in a given weight of fuel, but owing to the small percentage of binder added, this increase is relatively slight. But the briquets have the advantage over the coal in that their burning is accompanied with less waste and they permit a better-regulated and more complete combustion to take place. In this way the heating value actually obtained from the fuel, weight for weight (and this, of course, is the important consideration), may be materially increased by the manufacture of the fuel into briquets. This increased heating value of the briquets over that of the slack used thus becomes a matter of practical importance.

The evaporation results should at least equal those of the best lump coal from the screenings and dust of which the briquet was made.

CONDITIONS GOVERNING THE USE OF BINDERS.

MAXIMUM COST ALLOWABLE FOR BINDER.

The output of a briquet plant depends to a very great extent on the size of the briquets manufactured. The cost of labor depends greatly on the size and arrangement of the plant and on the wages paid, which will vary considerably in different localities. The price of slack coal and of the different binders is even more dependent on the locality. An approximate idea of the total cost of manufacture, exclusive of the cost of the slack coal and the binder used, is here presented, in order to consider intelligently estimates which may be made of the maximum allowable cost of the binder, it being obviously useless to investigate a binder that could never be commercially used on account of its cost. E. Loze[a] estimates the cost for manufacture in France at 33 to 40 cents per ton. Schorr[b] states that the cost in France is 24 to 34 cents per ton; in Germany, 22 cents to 24 cents; and in England, 24 cents. Estimates of the cost in the eastern and western parts of the United States are as follows:

Estimated cost per ton of manufacture of briquets in the United States (exclusive of binder and of coal briquetted).

	Western States.	Eastern States.
Labor, inclusive of stacking	$0.16	$0.20
Oil and grease	.006	.01
Sundry stores	.01	.01
Steam (fuel)	.04	.17
Depreciation	.05	.10
	.266	.49

Considering 30 to 50 cents per ton, therefore, as being approximately the cost of manufacture, it appears that when the difference in price between the slack coal and the first-class lump coal is $1, the binder must cost less than 50 to 70 cents per ton. Good briquets would probably find in many places a market at a price slightly advanced over that of the corresponding lump coal from the screenings of which the slack was derived. Yet it is evident that the main problem in briquetting is to find a suitable binding material at a cost sufficiently low. A binding material costing as much as $1 per ton of briquets produced could be used profitably in but few places in the United States. Even allowing for future possible greater variation in price between the coal and the slack it is not necessary to pay attention to any binding material costing above $1.25 per ton of briquets produced.

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[a] Eng. and Min. Jour., vol. 76, 1903, pp. 277, 431.

[b] Trans. Am. Inst. Min. Eng., vol. 35, 1904, p. 100.

QUALITIES DESIRED IN BINDERS.

It is needless to say that a desirable binder should make a good briquet and should make it cheaply. The characteristics of a good briquet have already been pointed out. It will not, perhaps, be too great a repetition to summarize here, in the approximate order of their importance, the desirable qualities of a binder, as follows:

1. It must be sufficiently cheap to make the manufacture of briquets profitable.
2. It must bind strongly, producing a briquet sufficiently hard, but not too brittle.
3. It must hold the briquet together satisfactorily in the fire.
4. It must produce a briquet sufficiently waterproof to stand the conditions of use.
5. It should not cause smoke or foul smelling or corrosive gases, or foul the flues.
6. It should not increase the percentage of ash or clinker.
7. It should increase, or certainly not diminish, the heat units obtainable from a given weight of fuel.

EFFECT OF QUALITY OF BINDER ON THE BRIQUET.

SCOPE OF THE INVESTIGATIONS.

The behavior of a large number of different coals with a few binders and of a few coals with a large number of different binders has been very carefully studied. Tests were made with each coal and with each binder until the percentage of binder required to produce a satisfactory briquet with that coal was determined. The behavior of the briquets in the fire and, when necessary, in water was noted. The binders used were examined as to their chemical or physical properties and such modification of the binder was made as seemed likely to produce more efficient results.

The conclusions that follow are submitted as the net result of the studies thus outlined.

PHYSICAL RELATION OF COAL AND BINDER.

The relation between the coal and the binder is purely physical. Chemical action, if coming into play at all, is so slight in amount as to be wholly negligible. Moreover, the properties of the binder are not greatly changed by the mutual solubility, or surface action, of coal and binder at the surface of the coal.

The above statements are shown to be true by the fact that if the coals are arranged in a series according to the percentage of one binder required, they will retain that same order when other binders are used, even when these binders are of the most diverse nature. The experiments of Constam and Rougeot[a] show that the soluble portion of the binders (various pitches) could be extracted from the briquets practically quantitatively with carbon disulphide, and that this reagent extracted at the most only 0.7 per cent from the coal.

The properties of the briquet are the properties of the coal plus the properties of the binder, and the combination of the two in briquetting does not materially change the properties of either. Not only is this observation true of briquets at ordinary temperatures, but it is also confirmed by their behavior in the fire. The decomposition of the binder caused by the heat may alter its character to some extent, but never, so far as the writer has observed, sufficiently to mask its original character. The action of the briquet in air and in water also confirms the truth of the above observation.

QUALITIES OF BINDER IMPARTED TO BRIQUET.

If the binder is brittle the briquet will be relatively brittle at the same temperature. Thus rosin, hard pitches, asphalts, cements, etc., make briquets that are hard, but they break easily from a sharp blow or fall. Liquids such as coal tar, creosote, asphalt tar, etc., make briquets that do not break easily from a fall, but they yield so readily to pressure as to be useless. Comparable percentages of binder being used, the toughest briquet—that is to say, the briquet that will stand the most rough usage—is made with a binder that at ordinary temperature twists easily and pulls into threads, that will cut with a knife rather than break, and that flows very slowly, taking some time to assume the shape of the container. Such a binder is sufficiently elastic not to be brittle and is sufficiently stiff not to yield to climatic changes of temperature. Binders that have been examined fulfilling this condition are pine-wood tar (12),[b] water-gas tar pitch (39), wax tailings (40), and residuums from petroleum, often designated as asphalts (37 A, 37 B, and 37 C). Satisfactory briquets are made with 3 to 5 per cent of the above binders. If the coal does not cake readily a binder with a higher melting point would be required to make the briquet retain its shape in the fire.

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[a] Zeitschr. f. angew. Chemie, vol. 17, No. 26. p. 1.

[b] Numbers refer to list on p. 22.

BEHAVIOR WHEN HEATED.

The binder will soften when in the briquet as soon as it is heated to the temperature at which it softens when outside of the briquet. Such softening will not be so apparent, however, for the binder exists in the briquet as a very thin coating over the grains, and if it melts to a thick, sticky liquid, rather than to a limpid one, its cohesive power in the state of a liquid is still very great. But it must be borne in mind that all briquets have a temperature of maximum weakness in the fire. This temperature lies in the interval between the melting or destruction of the binder and the softening of the coal as it commences to cake.. If the coal softens at a high temperature the binder must melt at a relatively high temperature to give satisfactory results in the fire. If the coal does not cake at all, then the binder must not melt at all, or be destroyed by the heat, if a perfectly coherent briquet at all temperatures is desired. Only inorganic binders could fulfill this condition, and their use is objectionable. Organic binders that do not melt, such as starch, etc., give the best results in the fire with a noncaking coal, but are not waterproof.

In a furnace the briquet does not become thoroughly heated throughout at the same time, and as the binder near the surface of the briquet melts and passes out as a gas, the binder in the next interior layer of the briquet to some extent takes its place, and so on. In this way the briquet is held together until the coal at its surface softens and cakes. When this happens the briquet commences to regain its strength and with many coals soon becomes stronger than when placed in the fire.

The binder will volatilize out of the briquet and appear as a gas as soon as it reaches the temperature at which it boils when outside of the briquet and in the pure condition. If this happens much below the kindling temperature of the gas some smoke and odor will be caused, and the smoke and odor may to a large extent be taken as proportional to the low-boiling oils in the binder—at least so far as the smoke is caused by the binder and not by the coal.

SOLUBILITY.

If the binder used is to any extent soluble in water the briquet will not withstand exposure to wet weather. The binder will go into solution as surely, though more slowly, in the briquet, as when it exists in the pure condition outside of the briquet, unless the briquet is in some way rendered waterproof.

QUANTITY OF BINDER NECESSARY.

SURFACE TO BE COATED.

The fact that the binder exists unchanged in the briquet, its office being solely to coat the grains, fill up void spaces between the grains, and by its adhesive and cohesive properties hold the briquet together, points to the following conclusions.

The amount of binder required will depend on the amount of surface to be coated, and the amount of surface will depend on the size of the grains, on their density (that is, the density of the dry coal), and on the capillary pores in the coal. The theoretical relation between the amount of surface to be coated, the size of the grains, and the density of the coal can be easily computed.

Let w = weight of coal taken. Suppose the grains of coal to be spheres, and let r = radius of the sphere. Let d = density of the coal. Then the volume of the sphere is $\frac{4}{3}\pi r^3$. The weight of the sphere is $\frac{4}{3}\pi r^3 d$. The number of grains of coal in the weight of coal taken is $\frac{w}{\frac{4}{3}\pi r^3 d.}$ The surface of each grain is $4\pi r^2$, and the total surface to be coated is $\frac{3w}{rd.}$

That is, the amount of surface to be coated varies inversely with the density of the coal and inversely with the diameter of the grains. The same law can be shown to apply whatever the shape of the grains.

The practical bearing of this relation is important. Thus, suppose a coal of density 1.4 requires 6 per cent of pitch to make a satisfactory briquet. Then a coal of density 1.1, other things being the same, would require 7.63 per cent of pitch, or 1.63 per cent more pitch than is required by the denser coal. This is one reason why lignite coal with a low specific gravity requires more binder than the average coal.

The variation in the size of the grains of coal has an even greater influence on the amount of binder required. The table below shows the relative amount of surface to be coated in coal slack of varying degrees of fineness:

Relation between size of grains and amount of surface.

Number of meshes to inch.	Diameter of wire (inch).	Size of mesh (millimeters).	Relative amount of surface.	Number of meshes to inch.	Diameter of wire (inch).	Size of mesh (millimeters).	Relative amount of surface.
1	0.131	25.400	1	80	0.00575	0.230	110
2	.103	12.700	2	100	.00450	.170	150
4	.079	6.350	4	200	.00235	.085	300
10	.027	2.000	12.7			.005	5,080
20	.01650	1.000	25.4			.0025	10.160
30	.01375	.670	37.9			.00075	33,900
40	.01025	.500	50.8			.00025	101,600
50	.00900	.310	81.9				

It will thus be seen that coal slack which will just pass a 20-mesh sieve has 6.35 times as much surface to be coated as the same weight of slack crushed so as to pass a screen of ¼-inch mesh, and that coal passing a 200-mesh sieve has 75 times the surface of coal just passing the ¼-inch mesh. The very finest dust, having a diameter of 0.00025 millimeter, has 25,400 times the surface of coal just passing the ¼-inch mesh.

This consideration is not purely theoretical. The remark of Wagner,[a] that it took 20 per cent of pitch to briquet certain fine coal dust, is illustrative of its practical bearing. The degree of fineness of the slack coal used is one of the main factors in determining the percentage of binder necessary to produce a satisfactory briquet.

To illustrate this point, mention is here made of a fact shown later, that all coal-tar pitches contain a certain amount of carbon (soot), which, being in a very finely divided condition, is not only inert so far as binding the coal together is concerned, but itself requires a binder. Owing to the dustlike condition of this carbon its effect on the binding power of the pitch for the coal is most marked. Thus, although a coal-tar pitch (28 G) that contained 14 per cent of this inert, finely divided carbon made a satisfactory briquet with Illinois No. 4 coal when 6 per cent of the pitch was used, yet another coal-tar pitch (28 I) containing 37 per cent of the inert carbon failed to make a satisfactory briquet with the same coal when 14 per cent of the pitch was used. On the market the pitches sell at approximately the same price. The serious mistake made in crushing coal slack too fine is apparent.

Fine crushing of the coal slack gives the briquet a smoother surface that is more resistant to the weather; but this increase in the quality of the briquet is usually obtained at too great a cost, owing to the additional binder required, as explained above. Fine crushing also makes the briquet somewhat harder to ignite.

Capillary pores increase the amount of surface to be coated and the amount of void space to be filled, and this is probably another reason why lignites require more binder than hard coals.

It is interesting, in this connection, to note that with all binders the coherence in the briquets at first increases but slowly with increase in the proportion of binder. Then suddenly the coherence increases very rapidly and the briquets become strong. Then when an excess of binder is added the increase in strength is again only slight. The curve takes the form indicated in the accompanying diagram (fig. 1). The explanation, of course, lies in the fact that at first there is not enough binder to coat all the grains of coal and there can be little coherence. When sufficient binder has been added to coat the grains, the strength increases rapidly. After the grains have been well coated there is little further gain in strength with the use of additional binder.

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[a] Cassier's Magazine, vol. 11, 1896, p. 23.

PERCENTAGE OF VOIDS.

The amount of binder will depend on the amount of void space to be filled. There should always be enough of the finer coal and coal dust present to fill the spaces between the larger grains, or binder will be required to fill these spaces. Thus Wagner also found that a very large amount of binder was required to bind coal slack of a uniform size, five-sixteenths to three-eighths inch in diameter. Clifford Richardson, in a recent book on "Modern asphalt pavements," gives a calculation by Dr. G. F. Becker, of the United States Geological Survey, as to the amount of void space. This calculation is in outline as follows:

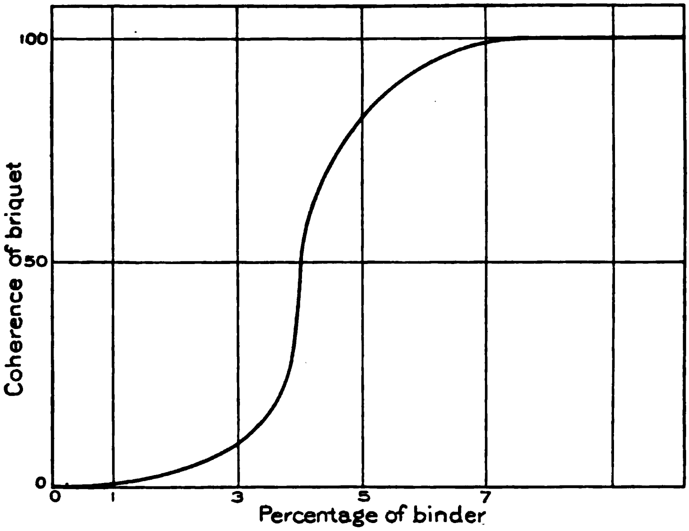

FIG. 1.—Curve showing relation between percentage of binder (water-gas tar pitch) and coherence of briquet. Other binders show similar curves, but with different percentages.

Consider four spheres in a plane so arranged that the lines joining their centers form a square, and four other spheres above them. A cube is formed by the lines joining the centers of the eight spheres. If r is the radius of a sphere, then the volume of the cube is $8\ r^3$ and the void space is $8\ r^3 - \frac{4}{3}\ \pi\ r^3$, and the percentage of void space is $\frac{8\ r^3 - \frac{4}{3}\ \pi\ r^3}{8\ r^3} = 1 - \frac{\pi}{6} = 0.4764$. If the spheres are placed obliquely, then the area of the parallelogram joining their centers is $2\ r^2\sqrt{3}$, and multiplying this by the height of a tetrahedron formed by the centers of four spheres when three are placed in contact in one plane and the fourth is placed on them, we have for the volume of the prism $4\sqrt{2}\,r^3$. Then for the percentage of voids we will have

$$\frac{4\sqrt{2}\,r^3-\frac{4}{3}\pi r^3}{4\sqrt{2}\,r^3}=1-\frac{\pi}{3\sqrt{2}}=0.2595.$$

From these results it will be seen that the amount of void space between grains of uniform size is independent of the size of the grains. In practice, however, even shot will not pack quite so closely as the theory indicates, as is shown by the experiments of Richardson, who found that with shot the percentage of void space was about 32.[a]

With grains of sand of uniform size but of irregular shape Richardson found the void space to average 43.6 per cent. It may be said, therefore, that in briquetting coal, 56.4 per cent of the total weight of the slack should be in grains about one-fourth inch in diameter.

It is interesting to obtain some idea of the desirable fineness of the remaining coal particles. Without giving the calculation in detail we may say that theoretically the spheres fitting in the spaces between the larger spheres, and the yet smaller spheres fitting into the void places then left can be calculated. The calculation shows that if r represents the radius of the large sphere there would be for every large sphere one smaller sphere having a radius of .4142 r, two spheres having a radius .2247 r, five spheres having a radius .1763 r, and eight spheres having a radius .1543 r. The volume occupied by these smaller spheres will be 11.14 per cent of the total volume, and since the large spheres occupy 74.05 per cent of the total volume, we would have about 15 per cent of void space to be filled in by yet smaller spheres. With irregular grains the results would not follow the theoretical percentages; but in a general way it is apparent that although it is advantageous to have a large percentage of the grains coarse (say 60 per cent of ¼-inch diameter), yet a considerable amount (say 40 per cent passing a 20-mesh sieve) of the finer slack and dust must be present to fill the voids.

The coal used in briquetting being already for the most part fine slack, the best practical results will be obtained by not breaking any of the lumps that are larger than one-fourth inch in diameter more than is necessary to bring them to that diameter and by not crushing the finer coal at all.

THICKNESS OF COATING.

The amount of binder necessary will depend on the thickness of the coat of binder over the surface of the grains of coal. The thickness of the coat of binder required will vary both with the coal and the binder, but principally with the binder. In general, it may be said that the binder should be dissolved or heated until it is in the condition of a thin liquid capable of wetting the grains, somewhat as water would. With the harder pitches or asphalts, and similar binders, superheated steam for the mixers is a matter of necessity for economical working, for otherwise the binder does not become sufficiently liquid to spread in a thin coat and is therefore wasted.

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[a] This is partly accounted for by the fact that the discussion of Doctor Becker does not consider the contact of the spheres with the walls of the container.—J. E. M.

OTHER CONSIDERATIONS.

The amount of binder required will depend to a slight extent on that portion of the coal which, being soluble in carbon disulphide, may be regarded as "bitumen" and as having some binding power. Constam and Rougeot[a] never found the amount of carbon disulphide extract to exceed 0.7 per cent, and probably with most coals the amount is negligible.

If the coals are arranged in a series according to the percentage of one binder required they will retain that same order in the series when other binders are used. Furthermore, if the equivalent percentages of different binders are determined for one coal then these equivalent percentages can be used for all coals, slight modifications only being sometimes necessary. An advantageous arrangement would be to place coals as ordinates and binders as abscissas in a table, and then the percentages of any binder required with any coal could be read directly.

LABORATORY INVESTIGATIONS OF VARIOUS BINDERS.

METHODS AND SCOPE OF THE EXAMINATION.

DETERMINATION OF PERCENTAGE OF BINDER.

In order to determine in the laboratory the percentage of pitch necessary to briquet a given coal, 20 grams of coal, unless otherwise stated in the detailed report, was weighed out, mixed with the chosen percentage of binder, and placed in a Battersea crucible. A small amount of water was then added and the mixture heated, with sufficient stirring to mix the binder and coal thoroughly, until steam came off freely and only a small amount of water was left in the coal. The mixture while still hot was pressed in a small laboratory hand press, on which a pressure of 3,500 to 4,000 pounds per square inch was usually obtained. Each briquet made weighed about 5 grams, and thus four briquets were obtained as representing the test. The percentage of binder was varied in subsequent tests until the correct percentage to produce a satisfactory briquet was determined.

The percentage of binder was always calculated on the weight of the coal, consequently the percentage calculated on the weight of the briquet produced would be somewhat less. This is a matter of no consequence, however, as the method of grading the briquet was purely relative.

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[a] Zeitschr. f. angew. Chemie, vol. 17, No. 26, p. 1.

DETERMINATION OF COHERENCE.

The examination of the small briquets produced was somewhat crude—their coherence being determined by the way in which they crushed or broke. The briquets were graded by numbers as follows:

1. Very slight coherence.
2. Slight coherence.
3. Coherent, but not satisfactory.
4. Satisfactory.

4½. Excellent briquet; would stand rough handling.

5. A briquet stronger than necessary.

It was found somewhat difficult to compare extremely hard and brittle briquets with others not brittle but too soft. In all tests the intention was to produce a relative grading in which 4 would represent a satisfactory briquet for ordinary use. In actual work the coherence of the briquet could be varied to suit the demand of the customer, but in no case probably would such variation exceed the range represented by the numbers 3½ to 4½.

LIST OF MATERIALS STUDIED.

The materials used to bind the particles of coal together may be either organic or inorganic, and a very large number of substances have at various times been suggested and used for this purpose.

A list of the binders which have been examined is given below. An effort has been made to include in this list all binders which it was thought might be used commercially in the United States, as well as certain other substances which seemed fitted to throw light on the laws governing the action of the binder. Attempt was made to study such modifications and combinations of the different binders as it seemed might produce more efficient commercial results. For these latter modifications and combinations reference must be had to the detailed report.

INORGANIC BINDERS.

(1) Clay, (2) lime, (3) magnesia, (4) magnesia cement (magnesium oxide and magnesium chloride), (5) plaster of Paris, (6) Portland cement, (7) natural cement, (8) slag cement, (9) water glass.

ORGANIC BINDERS.

Wood products.—(10) Rosin, (11) pitch (rosin and tar), (12) pine-wood tar, (13) hard-wood tar, (14) Douglas fir tar, (15) wood pulp, (16) sulphite liquor (from paper mills).

Sugar-factory residues.—(17) Beet pulp, (18) lime cake, (19) beet-sugar molasses, (20) cane-sugar molasses.

Starch.—(21) Corn starch, (22) potato starch.

Slaughter-house refuse.

Tars and pitches from coal.—(23) Blast-furnace tar, (24) producer-gas tar, (25) illuminating-gas tar, (26) by-product coke-oven tar, (27) coal-tar creosote, (28) various grades of pitches from various tars.

Natural asphalts.—(30) Impsonite, (31) gilsonite, (32) maltha, (33) refined Trinidad, (34) refined Bermudez, (35) hard and refined asphalts (from impregnated sandstones, etc.).

Petroleum products.—(36) Crude oil, (37) residuum (asphalts, etc.), (38) water-gas tar, (39) water-gas tar pitch, (40) wax tailings, (41) acid sludge, (42) asphalt tar, (43) Pintsch gas tar, (44) Pittsburg flux.

INORGANIC BINDERS.

GENERAL STATEMENT.

The great disadvantage of inorganic binders is that they all add ash to the fuel. This means freight on just so much noncombustible material, less heat return for a given weight of fuel consumed, and an added amount of ash on the grate. All briquets made with inorganic binders are weak when first pressed and strengthen only gradually. Inorganic binders possess the advantage that they are not volatile, and hence the briquets, even when made from a noncaking coal or lignite, will stand up well in the fire without disintegration. They also have a tendency to lessen the smoke produced. This is due to the fact that the binder enables a somewhat slower and more complete combustion to take place and does not itself contribute any smoke to the fuel.

Another slight advantage sometimes claimed for certain of the inorganic binders, such as lime, water glass, and magnesia, results from the tendency of the calcium, sodium, and magnesium to combine with the sulphur, thus diminishing the escape of the sometimes objectionable oxidation products of that substance. This action would be the same if the calcium, etc., existed in the binder in chemical combination, as it occurs in calcium resinate. (See "Rosin," p. 30.) For the purpose of testing the above-mentioned claim, a briquet was made with Indiana No. 8 coal and 4 per cent of magnesium oxide. The briquet was dried and then burned. The sulphur in the ash (determined by the kindness of Mr. Somermeier) was found to amount to 0.44 per cent. As the sulphur in the coal was 3.72 per cent, it is evident that only a small fraction of the sulphur is retained by the magnesium oxide used as a binder. The same would probably also hold true for calcium and sodium compounds. It is thought, therefore, that the advantage thus gained is not great enough to merit consideration in practice.

Evidently the disadvantage resulting from the addition of any large percentage of an inorganic binder is too great to justify its use except as a matter of great saving in cost, or as a matter of necessity, in order to hold together in the fire some entirely noncaking coal and produce a low grade of fuel therefrom.

The essential results of the tests made with the different coals and binders are assembled in the table at the end of this report, wherein is shown the percentage of binder necessary to produce a satisfactory briquet with the coal considered.

The work of the laboratory can be regarded as sufficient so far as the negative results are concerned, but in all cases where the laboratory work seemed to promise commercial results the experiments should be repeated on a larger scale.

The inorganic substances which were tested are the only inorganic materials whose use as a binder on a commercial scale seemed even so remotely possible as to warrant testing in the laboratory. A list of other inorganic substances which have been suggested as binders, or as possible constituents of binders, would include chalk, alum, ammonium chloride (sal ammoniac), copper sulphate, sodium hydroxide, sulphur, potassium nitrate, calcium chloride, etc. That all these substances are totally unfit for such purpose appears at once from a knowledge of their properties, and they were not considered further.

DETAILED DESCRIPTION.

1. *Clay.*—The tests shown in the table (pp. 51–52) were made with a good sample of potter's clay obtained through Dr. J. H. Pratt. Clay is cheaper than coal and its cost, considered as a binder, is therefore a minus quantity.

The briquets when first taken from the press were extremely weak, many of them breaking while being taken out. The full pressure could not be given, for the coal would crush through the narrow, practically closed space between the molds and the bed plate. After drying, the briquets were hard and rather brittle. In water they fell to pieces completely and quickly. In the fire they hardened and stood up well, except those made of the noncaking lignite, California No. 1, which nevertheless stood up far better than with most binders and in comparison with the usual behavior of this lignite could be called very satisfactory.

Clay was used as a binder at one of the first plants established in this country, the Loiseau plant at Port Richmond, Pa. Trouble was experienced with the press used, the briquets when first made showing weakness. This was finally overcome, but the binder was abandoned owing to the expense of drying and waterproofing the product. Briquets made at this plant with clay were said to be very satisfactory in the fire.

Any press using clay for a binder would probably have to be specially adjusted. Owing to the large addition of ash, and to the expense of drying and waterproofing the briquet, it is improbable that clay will ever prove advantageous as a binder. If used alone it can only be for the manufacture of a poor grade of fuel, incapable of standing any exposure to rain.

Clay in connection with other binders may be regarded as an adulteration of very doubtful value to the consumer.

2. *Lime.*—Lime, or rather, milk of lime, $Ca(OH)_2$, has often been suggested as a binder, and is said to have been used. The tests shown in the table were made with calcium oxide known to be chemically pure. In these tests the lime was mixed dry with the coal, and then water was added. In some of the tests an excess of water was added and later boiled off; in others an excess of water was added and then squeezed out in the press; and in yet others only sufficient water was added to thoroughly moisten the mass. After drying, all the briquets were very weak, those in which the largest percentage of calcium oxide was used being the worst. They finally disintegrated, merely from exposure to the air.

From these tests it is difficult to understand how it is possible to use lime alone to make a briquet. For further experiments with lime see "Rosin," (p. 30).

3. *Magnesia.*—The sample of magnesia tested was a light, calcined magnesium oxide. In the tests shown in the table (pp. 51–52) the magnesium oxide was mixed with the coal and then a sufficient amount of water was added. In some tests the briquet was pressed cold and in others more or less of the water was evaporated. The results show that 3 to 5 per cent of this binder would make a satisfactory briquet, except with certain lignites. The briquets are very hard and would stand heavy pressure, but are brittle if less than 4 per cent of binder is used. In water the briquets go to pieces, though far less rapidly than those made with clay. In the fire they behaved very well, some being satisfactory even when only 2 per cent of binder was used.

In the United States magnesite, from which magnesia is obtained, is found only in California, where the production of magnesium oxide in recent years has been as follows:

Quantity and value of magnesia produced in the United States, 1901–1906.

Year.	Quantity.	Value per ton.[a]	Year.	Quantity.	Value per ton.[a]
	Short tons.			*Short tons.*	
1901	1,666	$7.56	1904	1,357	$8.22
1902	1,349	7.56	1905	1,873	9.76
1903	1,750	7.27	1906	3,714	7.56

[a] Based on value of raw magnesite, with 10 per cent added to cover cost of manufacture of magnesium oxide therefrom, being a suggestive approximation only.

The production could be greatly increased, several million tons of the magnesite being now in sight. The mineral is calcined for the production of carbon dioxide, leaving the magnesia, which is used principally for covering steam and heating pipes, by paper mills, and in the manufacture of bricks for lining open-hearth furnaces and converters.

At the price prevailing in 1903, the cost of 3 per cent of this binder would be about 22 cents per ton of briquets produced. Three or four per cent of ash added to the fuel would not be greatly injurious, and the binder would possess an advantage over organic binders in holding the briquet together in the fire and in reducing the smoke.

The claim that the magnesia in the briquet reduces the amount of sulphur that escapes from the coal, as already pointed out (p. 23), seems to be of no practical importance.

It seemed possible that coke breeze might be briquetted with this binder, the briquets to be used in the place of coke in the furnace. Laboratory experiments on this point, however, gave unsatisfactory results, as follows:

Results of briquetting coke breeze with magnesia.

Percentage of binder.	Grade of coherence.[a]
3	3
4	3
6	4
8	4½

[a] See p. 22.

In water the briquet with 6 per cent of magnesia behaved fairly well and that with 8 per cent splendidly, but in the fire the briquet with 4 per cent was unsatisfactory, that with 6 per cent was only fair, and that with 8 per cent was very hard to ignite.

For results of experiments with mixtures of magnesia and organic binders see p. 49.

4. *Magnesia cement.*—In 1880 Dr. A. Gurlt recommended a binding material consisting of 30 parts of 45 per cent magnesium chloride, 30 parts of 93 per cent magnesium oxide, and 60 parts of water. He used 5 per cent of this material and says that it produced a stronger briquet than any other and that it adds only 2.5 per cent of ash. The statement as to the amount of ash (magnesium oxide) added is correct. The formula on examination, leaving out the water, is found to reduce to $5MgO.MgCl_2$. The evidence on which this formula was taken as the most advantageous for the cement is not stated. The results reported in the following table are based on the proportions shown for the formulas therein given:

Results of briquetting Illinois No. 11 B coal[a] *with varying formulas of binder.*

Formula.	Calculated for 2 per cent of magnesium oxide in the ash.			Calculated for 3 per cent of magnesium oxide in the ash.			Remarks.
	Amount of binder per gram of coal.		Grade of coherence.[b]	Amount of binder per gram of coal.		Grade of coherence.[a]	
	MgO.	$MgCl_2$ $6H_2O$.		MgO.	$MgCl_2$ $6H_2O$.		
	Gram.	*Gram.*		*Gram.*	*Gram.*		
$MgO.MgCl_2$	0.0100	0.0500	2½	0.0150	0.0750	3	
$2MgO.MgCl_2$	.0133	.0334	2½	.0200	.0500	3	Stronger than preceding.
$3MgO.MgCl_2$	.0150	.0250	2½	.0225	.0375	3	
$4MgO.MgCl_2$	.0160	.0200	2½	.0240	.0300	3	
$5MgO.MgCl_2$	.0167	.0167	3	.0250	.0250	3½	Apparently of about equal strength.
$6MgO.MgCl_2$	.0171	.0145	3	.0256	.0216	3½	
$7MgO.MgCl_2$	.0175	.0127	3	.0262	.0190	3½	
MgO	.0200	.0000	3	.0300	.0000	3½	

[a] Bituminous coal (one-half run of mine, one-half lump) from shaft near Carterville, Williamson County, Ill. For description, analysis, and tests see Bull. U. S. Geol. Survey No. 290, 1906.

[b] See explanation under "Determination of coherence" (p. 22).

In these tests the magnesium oxide was mixed dry with the coal, and then the magnesium chloride (dissolved in water) was added. As already stated, the method of testing the small briquets made does not allow of minute differences being noted, but the results showed clearly an increase of strength until the proportion given by Doctor Gurlt and represented by the formula $5MgO.MgCl_2$ was reached. On still further decreasing the proportion of the magnesium chloride the briquets apparently did not grow either weaker or stronger. Magnesium oxide is cheaper than the chloride, and in view of the results obtained there is considerable doubt as to the advantage of adding the chloride. The addition of the chloride is said to make a more quickly setting cement, and one that is more insoluble, owing to the formation of an oxychloride of magnesium, but the statement is not verified. The magnesium chloride would also have the disadvantage of losing its chlorine in the fire, and this might come off either free or combined with hydrogen as hydrochloric (muriatic) acid. In either case the resulting gas is exceedingly corrosive and would greatly injure the boiler flues. Possibly all of the chlorine would be retained by the coal ashes, but it is a matter of grave doubt.

In the fire briquets made with 3 per cent of magnesia cement of the formula $5MgO.MgCl_2$—that is, 3 per cent after calculating the formula to MgO—stood up well. In water they disintegrated after some time. It was not evident that the briquets with magnesia cement of this formula behaved any better in water than briquets made with the same ash percentage of magnesium oxide alone, if indeed they behaved so well.

Magnesium chloride is ordinarily sold in the market in the crystallized form $MgCl_2.6H_2O$. This grade is quoted at $20 per ton in large lots in New York. It is not produced to any considerable extent in this country, but should the demand arise could probably be made from the California magnesite without increasing the cost.

All the briquets made with the magnesia cement were very hard but very brittle. They would stand great pressure, but apparently would not stand rough handling, when only 5 per cent of the cement is used, as recommended by Doctor Gurlt.

5. *Plaster of Paris.*—Gypsum, the mineral from which plaster of Paris is produced, is widely distributed in the United States. In 1903 the production was 264,196 tons, valued at $4.08 per ton.

The tests shown in the table (p. 51) were made with plaster of Paris which was first mixed with the coal. Sufficient water was added to thoroughly moisten the mass, and then pressure was applied, the excess of water, if any, running out in the press. The briquets were very hard, but also brittle, and would not stand rough handling unless at least 12 per cent of binder was used. Even these were not first-class briquets. In the fire the briquet with 12 per cent of binder held together perfectly, and would have held together with a smaller percentage. In water the briquet went to pieces more rapidly than was expected.

Although even 12 per cent of plaster of Paris in a briquet would not be prohibitive as regards cost (50 cents per ton of briquets produced), it would be as regards the addition of ash, and would moreover cause a much slower combustion of the briquet. A briquet with 6 per cent shows considerable coherence and might be satisfactory for some purposes. For results of experiments with mixtures of plaster of Paris and organic binders see page 49.

6. *Portland cement.*—In 1903, 22,342,973 barrels of Portland cement, weighing 400 pounds gross each, were produced in the United States. The average value per barrel was $1.24, and allowing 20 pounds tare for the barrel, the value per ton was $6.52.

The sample of Portland cement tested was obtained from Mr. Richard L. Humphrey and was a mixture of seven well-known brands, constituting what has been termed typical cement. In the first tests made the cement was mixed with the coal, then an excess of water was added and largely boiled off, after which the coal was pressed. The results not being satisfactory, in subsequent tests less water was added and the mixture was not heated, but the results were only a little better. In the fire briquets with 12 per cent of binder held together well, and a smaller percentage would have been sufficient. In water the briquets went to pieces somewhat more rapidly than those made with plaster of Paris.

This binder is more expensive and certainly no better than plaster of Paris. For results of experiments with mixtures of Portland cement and organic binders see page 49.

7. *Natural cement.*—In 1903 the production of natural cement in the United States was 7,030,271 barrels, of 300 pounds gross weight each. The average value was $0.522 per barrel, equivalent to $3.73 per ton, allowing 20 pounds tare for the barrel.

The tests were made with a sample from Louisville, Ky., which was mixed dry with the coal and then sufficient water was added before pressing. The results were very nearly the same as with Portland cement, the briquets being hard and brittle. In the fire the briquets held together excellently, but in water they would not stand up particularly well. Natural cement would make a cheap binder but would have to be used in such large quantity as to be very objectionable.

8. *Slag cement.*—In 1903, 525,896 barrels of slag cement, of 380 pounds net weight each, worth $1.03 per barrel, equivalent to $3.42 per ton, were manufactured in the United States. Tests were made with slag cement as with the other cements, the results indicating its inferiority to either the Portland or the natural cement as a binder for coal slack.

9. *Water glass.*—Water glass, or sodium silicate, is produced to a considerable extent in the United States, 32,651 tons having been manufactured in 1900, with an average value of $12.74 per ton.

It is said that this material will make coherent briquets when 0.75 to 1 per cent is used. Two different samples were tested. The requisite amount was dissolved in hot water and mixed with the coal, any large excess of water was boiled off, and then the briquets were pressed. The results were unsatisfactory even when 12 per cent of binder was used. The experiments were then repeated with less water and no heat, but the results obtained were no more satisfactory. When the sodium silicate was analyzed one sample was found to contain only 86 per cent of the requisite amount of silica and 13.4 per cent of the requisite amount of sodium required by the formula for the normal silicate (Na_4SiO_4). The other sample, which behaved only a little better, showed on analysis 11.1 per cent of Na_2O and 27.4 per cent of SiO_2. These poor analyses may account to some extent for the lack of success obtained with the water glass, but the results are apparently sufficient to show that it is not suitable for use as a commercial binder.

ORGANIC BINDERS.

WOOD PRODUCTS.

10. *Rosin.*—In 1900, 300,000 tons of rosin, valued at $17.02 per ton, were produced in the United States. Of this amount, according to the Census report, only 7.6 per cent was used for domestic consumption. In 1905 the price of rosin, for even the lower grades, A to C, had risen to $29 per ton.

Rosin consists mainly of abietic acid or similar isomeric acids or anhydrides. The formula of this acid is given as approximately $C_{40}H_{56}O_4$, and its acid equivalent as 145 to 185. This means that if calcium oxide is used to neutralize the acid 0.0725 to 0.0925 gram should be added to 1 gram of the rosin to form calcium resinate.

The density of rosin ranges from about 1.07 to 1.08. Rosin softens at 80° C. and melts to a limpid liquid at 100° C. The melting point of abietic acid is stated to be 165° C. Rosin is entirely soluble in carbon disulphide.

The sample of rosin tested melted at 100° C. The tests made are shown in the table (pp. 51–52). The briquets withstood exposure to the weather well and, except those made with lignites, were satisfactory in the fire, though inclined to smoke.

An attempt was made to see if the addition of lime would improve the binding qualities of the rosin. Three grams of rosin mixed with 0.25 gram of lime melts to a thicker mass, more brittle than the rosin alone. If the amount of lime is increased to 0.50 gram the brittleness is very much increased. Experiments made on Illinois No. 6 B coal, with varying proportions of lime and rosin, gave the following results:

Results of briquetting Illinois No. 6 B coal[a] with varying proportions of rosin and lime.

	Percentage of rosin used.			
	2.	4.	6.	8.
First series:				
Lime added gram	0.033	0.067	0.1	0.133
Grade of coherence[b]	2	3	3½	3½
Second series:				
Lime added gram	0.066	0.134	0.2	0.266
Grade of coherence	2	2½	3	3

[a] Bituminous coal from Coffeen, Montgomery County. For description, analysis, and tests see Bull. U. S. Geol. Survey No. 290, 1906.

[b] See p. 22.

As 20 grams of coal were used the lime added in the first series was just sufficient to react with the rosin. The increase of lime appears from the above results to be detrimental, and the experiments were therefore not carried further. It appears that 6 per cent of rosin will be necessary to produce a satisfactory briquet with most coals, and inasmuch as rosin is now worth about $29 per ton its use as a binder is unprofitable. Nor is it likely that it will again become cheap enough to permit its use as a binder, either alone or in combination with other materials, such as tar.

11. *Pitch.*—Owing to fluctuations in the price of rosin, pitch, which is a mixture of rosin and tar, is variable in cost. In 1905 a good grade of navy pitch was quoted at about $35 per ton in St. Louis. The sample of pitch tested was of this grade. For the results of the tests made see table on pages 51–52.

Only 3 or 4 per cent of this pitch is necessary to produce a satisfactory briquet. The briquets stood the weather well and, except those made with the lignites, proved satisfactory in the fire.

The improvement of rosin as a binder by the addition of tar might have been predicted from the principles laid down, for rosin alone is too brittle to produce a tough briquet with a low percentage of binder, and thinning the rosin with a heavy oil, such as tar, thus making it less brittle, would doubtless be advantageous. However, even where only 3 per cent of pitch is necessary to produce a satisfactory briquet its cost will probably always forbid its use.

12. *Pine-wood tar.*—No accurate data as to the amount of tar produced in the United States could be obtained. The census of 1900 reported 84 wood-distillation plants, but these were mostly using hard woods. The tar produced should be from 4 to 10 per cent of the weight of the hard wood used, but no record of the output was made, the tar being mainly burned under the retorts. The number of distillation plants in the South using pine wood has been considerably increased since the census of 1900, and plants have also been erected to use fir in the northwest. Both pine and fir yield much larger percentages of tar than the hard woods, and it may be that in the future the tar obtainable from these sources will be available for briquetting plants in neighboring sections of the country. The census for 1900 showed exports of 36,535 barrels of tar and pitch, valued at $77,082, or $15 per ton. Pine tar is quoted at 6 to 10 cents per gallon, equivalent to $13.80 to $23 per ton.

In the distillation of wood various grades of oils and tars are produced, depending both on the wood used and on the manner of distillation. An examination of representative samples of these various grades was undertaken in order to determine their value for briquetting purposes and also to determine how the product could best be made suitable for such purposes.

A solid pine-tar residuum, obtained from Summerville, S. C., was designated 12 A. The final results of the tests made with this binder are shown in the table (pp. 51–52). All the briquets except those made of lignite behaved satisfactorily in the fire. The pitch softened at 80° to 90° C. to a very sticky mass that apparently should bind well, but some of the briquets, even with 10 and 12 per cent of the binder, were too brittle, although they were sufficiently hard. The poor results with this binder were attributed to the high percentage of carbon in the pitch and to the failure of the pitch to spread well over the grains of coal. The pitch dissolved readily in either wood-tar creosote or coal-tar creosote. The following tests were made:

Results of briquetting Arkansas and Illinois coals with varying proportions of pine-wood tar and creosote oil.

Coal.	Binder (per cent).			Grade of coherence.[a]
	Pine-wood tar 12 A.	Wood creosote oil.	Coal-tar creosote oil.	
Arkansas A	5	2	....	4½
	5	....	2	4½
Illinois No. 11 B	6	2	....	4
	6	....	2	4

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[a] See p. 22.

As was to be expected, these briquets smoke, but they stand up satisfactorily in the fire. The experiments show the improvement which may be made by thinning a pitch to the proper consistency. This holds also for coal-tar pitches, as will be seen later.

The pitch here discussed is a waste product, but being produced at only a few plants is not available in quantity.

A sample of very thick pine-wood tar, obtained from Cheraw, S. C., was designated 12 B. Its flowing point was 45° C. and only 3 per cent was volatile below 270° C., the volatile portion being mostly water. This tar had a density of 1.07. The results of the experiments made with it are summarized in the table (pp. 51–52).

The briquets produced some smoke, but were satisfactory in the fire except when made with lignite. They stood the weather well. This tar may prove an available binder for some briquet plants. It is obtainable at many wood-distillation plants at prices ranging from $15 to $20 per ton, and as only 3 to 4 per cent is necessary to produce a satisfactory briquet with most coals the binder would range in price from 45 to 80 cents per ton of briquets produced.

Another sample, of a slightly more mobile tar than 12 B, obtained from the same plant, was designated 12 C. Its flowing point was 42° C. and its density 1.05. About 14 per cent of this tar distilled below 270° C. The results of the experiments with it are given in the table (pp. 51–52). This tar is obtainable from any of the wood-distillation plants that could furnish tar like the sample 12 B, and would command about the same price. It contains a little more of the low-boiling oils—that is, those distilling below 270° C.—than sample 12 B, and requires about 1 per cent more of the tar to produce a satisfactory briquet.

A sample of pine tar obtained at St. Louis, Mo., was designated 12 D. It was liquid at 20° C. and had a density of 1.14. On distillation about 10 per cent came off below 200° C. and 25 per cent below 270° C. The following experiments were tried:

Results of briquetting Illinois No. 6 B coal with binder 12 D.

Percentage of binder.	Grade of coherence.[a]
2	3
4	3
6	3
8	3
12	4

[a] See p. 22.

The tar was evidently too liquid to produce satisfactory briquets. The residue left after distillation at 270° C. was then tested and gave a satisfactory briquet with Illinois No. 6 B coal when only 4 per cent of binder was used.

Another sample of pine-wood tar, obtained from a wood-distillation plant at Dunbar, S. C., was designated 12 E. It was found that about 5 per cent of this tar would produce a satisfactory briquet with Illinois No. 6 B coal.

Another sample of pine-wood creosote, obtained from Cheraw, S. C., was designated 12 F. This sample was liquid at 20° C. and had a density of 1.12. On distillation about 20 per cent by volume came off below 112° C., the distillate being mostly water, and 21 per cent more came off below 270° C. At 310° C. the residue swelled up and frothed over. The briquets made with this binder were not satisfactory, the reason being that the creosote was so thin that the briquets were easily crushed. They smoked in the fire, gave off the odor of creosote, and did not stand up well. The residuum left after the distillation of the creosote had been carried to 270° C. was tested with Illinois No. 6 B coal, the coherence being 3 and 4 with 6 and 8 per cent of binder, respectively.

A sample of pine-wood creosote, obtained from a plant at Dunbar, S. C., designated 12 G, was not tested, being similar to 12 F, with which no satisfactory results could be obtained. Another sample of turpentine oil obtained from the same plant, designated 12 H, was evidently of no value for briquetting purposes.

13. *Hard-wood tar.*—The sample of hard-wood tar examined was a rather thin liquid even at the ordinary temperature, and could not therefore make a sufficiently hard briquet. It had a density of 1.10. The following tests were made:

Results of briquetting Illinois No. 6 B coal with hard-wood tar.

Percentage of binder.	Grade of coherence.[a]
2	2
4	2
6	3
8	3
12	3½

[a] See p. 22.

On distillation below 112° C. the tar gave off 8 per cent of water; from 112° to 270° C. it yielded 44 per cent more of a light oil and of reddish paraffin oils. On testing the residue a satisfactory briquet was obtained with Illinois No. 6 B coal when 8 per cent was used as a binder. It is concluded, therefore, that the residue left from hard-wood tar after distillation to 270° C., where it is obtainable, could be used advantageously for briquetting.

14. *Fir tar.*—The sample of fir tar tested was obtained from a wood-distillation plant in the State of Washington. On distillation the tar gave off 8 per cent below 270° C. The results of the tests

are shown in the table (p. 51). As will be seen, the tar produces satisfactory briquets when 6 per cent is used.

Concerning the use of wood tar in general for briquetting, the conclusions to be drawn are that the distillation of the tar should in general be carried to 270° C., and the residue, which will be either a thick tar or a soft pitch, should be used. The briquetting qualities of a tar thus prepared will vary considerably with the source of the tar. Pine tar is best, about 4 per cent being required; fir tar comes next, about 6 per cent being required; and lastly, hard-wood tar, about 8 per cent being required to produce a satisfactory briquet. The work has not been extended to a sufficient number of samples of tar to make the above conclusions as regards the percentage of each tar required absolutely certain, but the percentages given will serve as the basis for a rough estimate of the cost of wood tar as a binder. In some localities this product might compete successfully with other binders.

15. *Wood pulp.*—The claim has been made that cellulose, which is the main constituent of prepared wood pulp, has binding properties, but a few experiments point to the conclusion that its use is wholly impracticable. Possibly the term was confused with lignocellulose, the lignone groups affording the main constituents of the sulphite liquor discussed in the next section.

16. *Sulphite liquor.*—In the manufacture of paper, wood pulp is treated with sulphurous acid to remove certain lignone groups, which combine with the SO_3H and are then removed in the waste water, in which they are soluble. This waste liquor, amounting to ten or twelve times as much as the cellulose fiber produced, yields on evaporation an average of 9 to 10 per cent of solid residues. Roughly, therefore, the amount of this solid waste material is equal to the amount of cellulose obtained. According to the United States Census report for 1900 the amount of sulphite fiber produced was 416,037 tons, and the estimate indicates that there was an equal production of the waste lignone complex.

Not only is this liquor a true waste material, finding at present no market, but its production is a great nuisance, for it very seriously pollutes the streams on which the mills are situated and gives rise to much trouble. Its cost, therefore, would be represented solely by the cost of getting rid of the excess of water and by the freight to the briquetting plant. The water could be removed by evaporation, during which process the complex groups are to some extent broken down, sulphur and sulphur compounds being formed and some of them escaping. Of the solid residue left from evaporation 20 per cent is inorganic material and 80 per cent is organic. An ultimate analysis of the lignone complex groups shows, according to Cross and Bevan, carbon, 50.22 to 56.27 per cent; hydrogen, 5.22 to 5.87 per cent; sulphur, 5.52 to 8.80 per cent.

Efforts have been made by various investigators to separate the lignone complex groups from the water by precipitation instead of by evaporation. It is possible that some process of settling and filtration may recover the desired gummy residues without going to the expense of evaporating the water, but the processes so far devised are as yet unsuccessful on a commercial scale.

The sample of sulphite liquor examined was obtained from Detroit, Mich. On evaporation it showed a dry residue of 11.8 per cent. This residue, of course, does not melt but chars and decomposes if heated to a high temperature. Before evaporating quite to dryness the residue is a very sticky, gummy mass, easily soluble again in water. The original liquor was evaporated to about one-third of its bulk and when in this condition was used in the following tests:

Results of briquetting California lignite[a] *and Illinois coal with sulphite liquor.*

Percentage of binder.	Grade of coherence.[b]	
	California No. 1.	Illinois No. 6 B.
2	....	2
4	....	2½
6	....	3
8	....	3½
10	3½	4
12	4	4½

[a] Lignite from Tesla, Alameda County. For description, analysis, and tests see Bull. U. S. Geol. Survey No. 290, 1906.
[b] See p. 22.

The briquets from Illinois No. 6 B coal, with 10 per cent binder, and from California No. 1, with either 10 or 12 per cent binder, were satisfactory in the fire. The briquets made from the California lignite show the good effect of using a binder which does not volatilize or melt, for this coal is one of the most difficult of all the coals with which to obtain satisfactory results in the fire. In water, of course, the briquets will go to pieces rapidly.

It must be remembered that the above percentages of binder refer not to the dry residue from the sulphite liquor, but to the liquor itself when concentrated only to one-third of its bulk. To compare the results with the dry material the percentages must be divided by three. In other words, we have from the paper mills each year 1,200,000 tons of waste material which will produce coherent briquets when 10 to 12 per cent of it is used as a binder. The drawback to its use is the fact that the briquets are not waterproof, and a few preliminary experiments were made in an endeavor to overcome this difficulty, with the following results:

Results of briquetting California lignite and Illinois coal with varying proportions of sulphite liquor and other binders.

Coal.	Binder (per cent).			Grade of coherence.[a]	Fire test.	Water test.
	Sulphite liquor.	Waterproofing constituent.				
		Material.	Amount.			
California No. 1 (lignite)	8	Pitch 39	4	4	Fair	
	8	do.	8	4	O. K.	Fair.
Illinois No. 6 B	6	Coal-tar creosote	4	3¼	O. K.	
	6	Asphalt tar	4	4	O. K.	Fair.
	6	Pitch 39	4	4	O. K.	Fair.

[a] See p. 22.

These experiments indicate that oils and pitches mixed with the sulphite liquor will render the briquet more or less waterproof, depending on the extent and character of the added constituent. The whole problem is an important and promising one and deserves further investigation.

SUGAR-FACTORY RESIDUES.

17. *Beet pulp.*—Several samples of beet pulp (a waste product) were examined and carefully tested in the hope that they might contain sufficient starchy or sugary material to serve as a binder. The results showed that the pulp could be of no use whatever for this purpose. Details of the tests need not therefore be given.

18. *Lime cake.*—The sample of lime cake examined proved to be practically pure calcium carbonate, which could be of no possible use in briquetting.

19 and 20. *Beet-sugar molasses and cane-sugar molasses.*—The binding power of molasses is said to be due to pectin, which is a body closely related to mucilage and has the constitution of a typical lignocellulose. To a less extent the binding power is due to sugar. Molasses contains only about 10 per cent of ash. From 1 to 1.5 per cent of molasses in water is said to be sufficient for binding, but the experiments do not verify the statement. Three samples of beet-sugar molasses were examined—19 A, 19 B, and 19 C. Samples 20 A and 20 B were cane-sugar molasses. The moisture and ash were determined as follows:

Moisture and ash in beet-sugar and cane-sugar molasses.

	Beet-sugar samples.			Cane-sugar samples.	
	19 A.	19 B.	19 C.	20 A.	20 B.
Moisture per cent	12.5	13.8	21.8	27.3	27.5
Ash do	8.1	10.1	9.9	6.3	5.7

Tests in briquetting Illinois No. 6 B coal with these samples gave the following results:

Results of briquetting Illinois No. 6 B coal with varying percentages of beet-sugar and cane-sugar molasses.

Percentage of binder.	Grade of coherence.[a]				
	19 A.	19 B.	19 C.	20 A.	20 B.
2	3	2	......	......	......
4	3	3	2	2½	2
6	3	3	3	3	3
8	3	3	3	3	3
12	3	3	3	3	3

[a] See p. 22.

The coherence of the briquets did not seem to be increased by using more than 6 per cent of molasses. The failure to obtain good briquets with smaller percentages or to obtain satisfactory briquets even when the higher percentages were used is hard to explain. Heating the briquets to a higher temperature, even to 150° or 160° C., did not seem to improve them. Their behavior in the fire could not be regarded as very satisfactory. In water they fell to pieces.

Some experiments were made with lime and molasses and also some attempts to waterproof these briquets, but no very satisfactory results were obtained. The use of molasses as a binder needs further investigation before it is finally classed as being of no use for briquetting, but so far it would seem to be without commercial value for this purpose.

The census report for 1900 showed that there were 3,551,856 gallons of this molasses produced, valued at $25,102 for the portion sold. Much of it went to waste.

STARCH.

21. *Cornstarch.*—In the tests of cornstarch it was first necessary to determine if heating the starch with water to a paste, thus forming dextrin, before mixing it with the coal was essential, or if the change of starch into dextrin would take place as well when the starch was first mixed with the coal and the mixture then moistened and heated. The experiments showed that the latter procedure was fully as effective. Starch was tested more particularly with the lignites, because it does not evaporate before burning, and hence would hold the lignite together in the fire. The results of the tests are shown in the table (pp. 51–52). In all the tests the behavior of the briquets in the fire was far more satisfactory than if pitch or a similar binder had been used. Starch possesses the advantage over such binders that it adds no smoke-producing material to the coal.

In water these small starch briquets fell to pieces in a few minutes, and the next endeavor was to waterproof them. Many attempts were made to accomplish this end by immersion in oil. The experiments indicated that any oil would waterproof the briquet when externally applied, but asphalt tar, which was the thickest oil tested, gave the best results. It is doubtful if external waterproofing with a thick oil would ever be commercially successful, owing to the cost and difficulty of manipulation, but a thin oil, such as crude petroleum, might answer. At any rate, laboratory tests with small briquets can not finally decide the point, and the experiments should be conducted on a larger scale.

An endeavor was also made to waterproof by mixing the coal and starch with some of the oils before briquetting. For this purpose Hoffman's petroleum, Kansas crude oil, coal-tar creosote, asphalt tar, water-gas tar pitch, coal-tar pitch, and hard-wood tar were used under varying conditions and with varying percentages both of the starch and of the oils. The experiments indicate that the presence of crude oil or tarry liquids is detrimental to the action of the starch, both as to coherence and in the fire. But the binding power of the starch, though somewhat diminished, was nevertheless still very great, and it is probable that a briquet with 1 per cent of starch and 8 per cent of a heavy crude oil, or a less percentage of oil residue, would prove satisfactory. It is possible that in some places such a combination might prove the cheapest and most satisfactory binder obtainable. Pitches did not seem to injure the action of the starch, but unless a small percentage of pitch is found to waterproof there would be nothing gained by the combination. The experiments made did not seem to indicate that a small percentage of pitch with starch would give satisfactory results in the weather, but this point should be tested on a larger scale.

A patent for the use of starch as a binder was issued in 1858, in England, to John Piddington. He used 36 pounds of starch and 8 per cent of water per ton of coal.

The objections to starch as a binder are that the briquets do not immediately harden, and that they will not stand exposure to the weather unless made waterproof. The advantages of starch as a binder are its cheapness, its wide availability, the fact that it introduces no smoke, and the fact that, being nonvolatile, it holds the coal together well.

As shown by the census report for 1900 the amount of starch produced in the United States during that year was 297,803,139 pounds. Of this amount 247,051,744 pounds was made from corn as raw material, the average price of the starch being 2.5 cents per pound. It is of course not necessary that starch to be used as a binder be pure, and a far better idea of its cost for this purpose can be obtained by considering the cost of the raw material.

The raw materials available in the United States are corn, wheat and other small grains, Irish potatoes, sweet potatoes, cassava, and spoiled products containing starch. The starch from wheat and other small grains is more expensive than that from corn. Cassava, yielding 4 to 5 tons per acre and containing about 25 per cent of starch, offers a very cheap source of starch, but in the United States it can not be grown far north of Florida.

In 1900, 231,106 tons of corn were used for the production of cornstarch, the average price paid being $11.78 per ton. Corn contains 60 to 65 per cent of starch. The factories extracted on the average 53.4 per cent, and the cost of this starch in the crude condition is therefore $18.85 per ton. The only preparation necessary would be fine grinding.

The price of raw cornstarch may be estimated at $20 per ton, based on the census report for 1900, and inasmuch as only 0.5 to 1 per cent of this material is required to make a coherent briquet, it follows that the cost of starch binder of this kind per ton would be only 10 to 20 cents. The briquets would not stand rain, but would prove perfect if kept under cover. It seems that starch briquets, only slightly waterproofed, might be used during the dry season in certain sections of the West. If more thoroughly waterproofed with heavy crude petroleum oils they might be generally used. The crude petroleum would increase the fuel value of the briquet almost sufficiently to pay for itself. It seems, therefore, that further experiments with starch on a larger scale are desirable.

22. *Potato starch.*—Properly chosen varieties of the sweet potato contain about 22 per cent of starch and the yield per acre is large. Small, unmarketable potatoes may be used. The sweet potato is available in many parts of the United States.

The Irish potato is widely distributed, and starch factories consumed 118,000 tons in 1900, paying an average of $5.90 per ton and obtaining an average of 14.3 per cent of starch. As a rule only unmarketable potatoes were used and this accounts for the low percentage of starch obtained, the average yield of Irish potatoes being 18.2 per cent of starch, and some varieties giving as high as 25 per cent. On the basis of 18 per cent available starch, the raw starch obtained from this source is worth $32.75 per ton.

Usually, therefore, starch obtained from potatoes would be more expensive than that obtained from corn. A number of tests were made to see if the action of the two starches is similar. No difference in the coherence of the briquet or in its behavior in the water or in the fire was detected.

SLAUGHTER-HOUSE REFUSE.

Slaughter-house refuse, which is now largely made into glue, has been so often suggested as a binder that its cost was investigated. The census of 1900 showed that 34,750 tons of glue were produced, valued at $155 per ton. The price is therefore prohibitive and no experiments were made with this material.

TARS AND PITCHES FROM COAL.

Preliminary considerations.—The work done at the briquetting plant under the direction of Dr. J. H. Pratt had shown that there was great variation in the value of various coal-tar pitches for briquetting purposes. That work had also shown that coal-tar pitch would be one of the most important binders to be considered. An endeavor was made, therefore, to study the various grades of coal tar and the pitches therefrom, with the idea of improving the pitches and of establishing some method of examination which might reveal their value without the necessity of an actual briquetting trial.

The total production of coal tar in the United States in 1903 was 62,964,393 gallons, valued at $0.0349 per gallon, or $7.27 per ton.

On distillation coal tar is divided into several fractions which are more or less clearly defined. By further distillation these fractions are separated more completely and find their way to the market as illuminating oils, naphtha, creosote, etc. They consist of a very large number of chemical compounds. The manner in which coal tar is fractionated varies at different works, but as illustrative, it may be said that the ammoniacal liquor distils first, then the first light oils, boiling below 110° C. The second light oils come off at 110° to 170° C., the carbolic oils at 170° to 225°, the creosote oils at 225° to 270°, the anthracene oils at 270° to 360°, and lastly the pitch is left behind as a residue.

None of the oils coming off below 270° C. are useful in briquetting. The anthracene oils, which consist of a large number of different compounds, should not, however, be entirely distilled from the pitch if it is desired to use the pitch for briquetting. Nearly all the various constituents of both the pitch and the anthracene oils except the free carbon are soluble in carbon disulphide. Constam and Rougeot[a] examined 33 pitches obtained from various sources, and found the amount of carbon-disulphide extract to range from 60.43 to 91.22 per cent and to average 76.3 per cent. They also found the value of the pitch for briquetting purposes to be proportional to the amount of carbon-disulphide extract. The results obtained by the writer lead to the same conclusion, except that the free carbon (that is, the insoluble portion) is believed to be not only inert but detrimental to the pitch, indicating that the increase in the value of a pitch for briquetting purposes is somewhat greater proportionally than the increase in the percentage of extract obtainable. The free carbon seems to prevent the pitch from spreading easily over the grains of coal, and owing to its very finely divided condition itself offers a very large surface for the absorption of pitch.

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[a] Zeitschr. f. angew. Chemie, vol. 17, no. 26.

A pitch has no true melting point, but owing to the large number of different chemical bodies which it contains, softens only very gradually. This softening point of the pitch has a marked influence on its use in briquetting, for the pitch must either be so brittle that it can be broken finely and mixed with the coal as a solid, or it must be melted and distributed as a liquid. Many pitches soften at so high a temperature that they can not be efficiently used except by heating above 100° C. The pitch must therefore be adapted to the briquetting machine in which it is to be used. Many methods of determining the softening point of a pitch have been suggested, but most of them are either too troublesome for practical use or not accurate. In the experiments here recorded the flowing point of the pitch was used as an index of the temperature at which it softened. This point was determined by placing about 3 cubic centimeters in the bottom of a test tube one-half inch in diameter and inserting the tube in a bath. The temperature of the bath was raised until, on taking out the tube and inverting it, the pitch flowed 1 inch down the tube in fifteen seconds.

In ascertaining the value or suitability of a given pitch or tar for briquetting purposes three determinations are necessary:

1. The pitch or tar is distilled and all oils coming off below 270° C. are rejected as being of no value in briquetting.
2. The flowing point of the portion to be used in briquetting is determined. This should generally be not less than 70° C.
3. The pitch is extracted with carbon disulphide. The smaller the amount of residual carbon the more satisfactory the pitch.

It should be borne in mind that the higher the flowing point of the pitch the more satisfactory it will prove in the fire when used with coals that do not cake readily. If the pitch has too high a flowing point to be workable with the briquet machine at hand, it could be softened by the addition of a high-boiling coal-tar oil (above 270° C.) or of very soft pitch. Coal-tar creosote could be used, but its boiling point is too low to make its use in all respects satisfactory.

23. *Blast-furnace tar.*—As it was impossible to learn whether blast-furnace tar and the similar material known as shale tar are produced in the United States, no experiments were made with them.

24. *Producer-gas tar.*—Two samples of producer-gas tar were examined. The first, designated 24 C, after pouring off the water, gave on distillation, water, 30 per cent; oils below 270° C., none;

oils at 270 to 330° C., 6 per cent. From 330° the thermometer jumped suddenly to 370° and the distillation was stopped. The residue gave with Illinois No. 4 coal a satisfactory briquet when only 4 per cent was used as a binder.

The next sample, designated 24 D, was tested after boiling off the water. The result showed a satisfactory briquet with Arkansas No. 7 A coal when 4 per cent was used, but a larger percentage is necessary with most other coals and probably 8 per cent would be necessary for most lignites.

The tar obtained, when freed from water only, is rather too liquid to produce the best quality of briquet. But the removal of only about 6 per cent of oils raises the flowing point of the tar to about 70° C. and the residue appears, as above seen, to be excellently fitted for briquetting purposes. The amount of carbon-disulphide extract obtainable from the residue was not determined. It should not be large, for the temperature at which the tar is made is comparatively low. This is probably the cause of the superior binding power of the pitch.

The amount of this tar obtainable and its market value are questions for future determination.

25. *Illuminating-gas tar.*—About 25 per cent of the illuminating gas produced in the United States is made from coal, and the tar resulting from the process amounts to about 5 per cent of the coal coked. The census report for 1900 gives the production for 1899 as 67,094 tons. In 1903, 61.4 per cent of the coal tar made was produced in gas works. The average value of this tar as distinct from other coal tars is not obtainable, and $7.27 per ton, the average value of all coal tars for 1903, is therefore accepted as approximately correct for gas tar.

This tar is too liquid to produce good briquets. The oils coming off below 270° C. should be disposed of. The residue, equaling 70 per cent of the total, would cost $10.40 per ton, if the sale of the low-boiling oils could be made to pay the expense of the distillation and the profit thereon.

Pitches 28 A, 28 B, 28 C, 28 D, 28 E, 28 F, and 28 I, obtained from this tar, were examined, and the percentages determined as necessary to make satisfactory briquets are shown in the table (pp. 51–52).

26. *By-product coke-oven tar.*—In 1903, 38.6 per cent of the total coal tar produced (24,296,536 gallons) was produced in by-product coke ovens. The census report for 1900 shows that in 1899 only 3.33 per cent of the total coal coked was coked in by-product ovens. Consequently the amount of coal tar from this source could be enormously increased.

This tar is obtained by distillation at a high temperature, and therefore contains more fixed carbon than tar from illuminating-gas plants. About 60 per cent of the tar from an Otto-Hoffman oven is pitch.

The tar is too liquid to be used directly for briquetting. The results with pitches 28 G and 28 H, made from coke-oven tar, are shown in the general table (p. 51).

27. *Coal-tar creosote.*—The principles governing the use of binders make it appear useless to test coal-tar creosote alone. It is too thin a liquid to make coherent briquets and of too low a boiling point to give satisfactory results in the fire. This creosote could be used to thin a pitch whose boiling point is too high, when such use is advantageous. It could also be used to waterproof a binder that would not stand the weather; but this could be done as well with a crude oil of low specific gravity, and the cost would be less. Coal-tar creosote is worth about 6 cents per gallon.

28. *Coal-tar pitches.*—The pitch designated 28 A was obtained by Dr. J. H. Pratt, who called it pitch C in his report.[a] This pitch flowed at 100° C., and the behavior of the briquets in the fire was satisfactory.

The pitch designated 28 B was obtained through Dr. Pratt and was by him designated, in his report, pitch D. This pitch had a flowing point of 127° C. It was used in making a very large number of tests on the comparative action of different coals with the same binder.

The pitch designated 28 C was used to briquet 50 tons of Arkansas semianthracite slack, about 6.5 per cent being used. This pitch had a flowing point of 100° C. It proved too soft for use with a pitch cracker on a summer day.

The pitch designated 28 D was used to briquet 200 tons of Arkansas semianthracite slack, about 6.5 per cent being used. This pitch had a flowing point of 120° C. and was sufficiently brittle for use on the hottest day. It gave a carbon-disulphide extract of 67.75 per cent.

The pitch designated 28 E had a flowing point of 100° C.

The pitch designated 28 F was very soft, having a flowing point of 68° C., and did not prove as efficient a binder as its appearance indicated. No further examination was made to determine the cause of the trouble.

The pitch designated 28 G was a soft coke-oven pitch obtained from tar produced in the Semet-Solvay process. It had a flowing point of 95° C. and yielded about 86 per cent of carbon-disulphide extract.

The pitch designated 28 H was a harder coke-oven pitch from the same source as 28 G. It had a flowing point of 100° C. and gave 81.50 per cent of carbon-disulphide extract. The briquets were possibly a little stronger than those made with the soft coke-oven pitch.

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[a] Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; Bull. U. S. Geol. Survey No. 261, 1905, p. 134.

The pitch designated 28 I was received through Dr. Pratt, who called it pitch X in his report.[a] It had a flowing point of 190° C., being very hard and brittle. The carbon-disulphide extract was 63.2 per cent. A large number of tests were made with this pitch when determining the qualities of binders in general in order to learn why this grade was so poor a binder. This seemed to be due to two causes—(1) the large amount of contained free carbon (36.8 per cent), and (2) the high softening point. At 100° C. the binder did not melt sufficiently to spread over the grains of coal to the best advantage.

To test this latter point the pitch was mixed with wood creosote 12 F, which did not itself possess sufficient binding power. Two hundred grams of pitch was mixed with 100 grams of the wood creosote and heated with stirring until thoroughly mixed. The resultant pitch, which was brittle enough to be pulverized if kept cool, was then tried with a number of coals and compared with the original pitch. The results from this mixture, designated 28 J, are shown in the table (pp. 51–52). It will be noted that in all the tests 4 per cent more of the original pitch than of the mixture was required, thus confirming the diagnosis of the trouble.

None of the coal-tar pitches gave coherent briquets with less than 6 per cent, and with many of them 7 or 8 per cent was required. The reason why a coal-tar pitch will not briquet if less than 6 per cent is used is that it contains a comparatively large amount of carbon. The residue from producer-gas tar made satisfactory briquets with 4 per cent, and this result was doubtless due to the fact that such tar contains little free carbon.

The cost of coal-tar pitch per ton may be taken as $11; therefore the cost of the binder per ton of briquets produced ranges from 66 to 88 cents. The briquets when properly made will stand exposure to the weather well. They will stand up satisfactorily in the fire if the coals cake at all readily. With noncaking coals the briquets would not prove satisfactory in the fire. This binder does not cause an undue amount of smoke.

NATURAL ASPHALTS.

Asphalts grade almost imperceptibly into heavy, thick petroleum oils. The designations used by Eldridge[b] have been followed in this discussion. Wurtzilite, nigrite, ozocerite, and grahamite occur in the United States, but not in deposits profitable to mine.

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[a] Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; Bull. U. S. Geol. Survey No. 261, 1905, p. 134.

[b] Eldridge, G. H., Origin and distribution of asphalt and bituminous rock deposits in the United States: Bull. U. S. Geol. Survey No. 213, 1903, pp. 296–305.

30. *Impsonite.*—Impsonite, sometimes called grahamite, is found in Oklahoma. It softens at a high temperature, but does not melt. In carbon disulphide 35 per cent or more is dissolved.

The sample tested was obtained through Dr. Pratt and was designated B 4 in his report.[a] This was tested with a lignite, as its only possible use in briquetting was considered to be to mix with a noncaking coal in rather large percentage. From 20 to 30 per cent was found to be required to hold a California lignite together in the fire. Even though the material is very cheap, the large percentage required prohibits its commercial use.

31. *Gilsonite.*—It is estimated by Eldridge that 32,000,000 tons of the asphalt known as gilsonite are now in sight in the extensive deposits that occur in Utah. He further states that the cost to mine does not exceed $1.75 per ton. The material has to be hauled a long distance to a railroad, and the present price in St. Louis is about $35 per ton. Gilsonite has a brilliant luster, burns and acts like sealing wax, and is entirely soluble in carbon disulphide. Two samples were tested.

The sample designated 31 A was black, with a brilliant luster, and flowed at about 250° C. In testing, the finely powdered material was mixed dry with the coal and heated far above 100° C. As shown in the table (p. 52) it gave a good briquet when 4 per cent was used.

The sample designated 31 B was black, with a less brilliant luster. When its flowing point was being determined it frothed out of the tube. It gave a briquet of satisfactory coherence when 6 per cent was used as a binder. The briquets are also satisfactory in the fire; and, owing to the high softening point of the binder, it would be very useful with noncaking coals. At its present price of $35 per ton, however, even 4 per cent of this binder is out of the question.

32. *Maltha.*—Small deposits of maltha, a liquid asphalt, occur in Oklahoma, Mexico, California, and Texas. In 1903 the only production reported to the Geological Survey was 58 tons from Texas, valued at $19.83 per ton.

The sample tested was obtained through Dr. Pratt and was called by him "liquid Austin asphalt." A satisfactory briquet was produced with 3 to 3½ per cent of binder. Attention is called to the fact that when as much as 8 per cent of this binder is used the briquet grows weaker instead of stronger. This is due to the low flowing point of maltha, 58° C., which causes the briquet to crush easily if an excess is used. In the fire the binder would give satisfactory results only when used with coals that cake very easily.

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[a] Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; Bull. U. S. Geol. Survey No. 261, 1905, p. 134.

The cost of this binder, 3 per cent being used, would be 60 cents per ton of briquets produced. With some coals a larger percentage would be necessary.

33 and 34. *Refined Trinidad asphalt and refined Bermudez asphalt.*—Considerable quantities of crude Trinidad and Bermudez asphalts are annually imported. In 1903 the imports of the former amounted to 129,133 tons, valued at $367,003; and of the latter 9,898 tons, valued at $48,218.

The cans in which samples were furnished for these experiments were not marked and complete identification was impossible. The softer of the two samples flowed at 115° C. and could not be powdered. It gave a satisfactory briquet when 6 per cent was used with Illinois No. 11 C (4) coal. The harder sample could be powdered, flowed at 180° C., and on testing showed a briquet that was hardly satisfactory when 8 per cent of the binder was used with Illinois No. 11 C (4) coal. If the binder had been superheated better results could probably have been obtained.

These asphalts apparently could not compete with coal-tar pitches as binders.

35. *Hard and refined asphalts.*—Bituminous sandstones, limestones, or shales occur in several States in deposits of considerable extent. These are mined, but usually the rock is used as a constituent of paving mixtures and the bitumen is not extracted. Attempts have been made to refine this rock either by distillation or by extracting the bitumen with a solvent, such as naphtha. The process does not seem to have been very successful commercially. The only production reported is 6,400 tons from California, with a value per ton of $21.87; and 877 tons from Indian Territory, with a value per ton of $17.61. No samples could be obtained, and the product is probably not now on the market.

PETROLEUM PRODUCTS.

36. *Crude oil.*—Unless they are of the consistency of maltha, crude oils are not suitable for binders, being too liquid. They might be used to advantage in waterproofing briquets made with starch, sulphite liquor, or molasses.

37. *Petroleum residuum.*—There are many grades of petroleum residuum depending on the base of the crude oil (that is, whether the oil has an asphalt base, or a paraffin base, or an asphalt and paraffin base), on the temperature at which the distillation is stopped, and on the amount of cracking to which the oil is subjected during the distillation.

In 1903, 46,000 tons of asphaltic residue, with an average value of $11.30 per ton, were produced from petroleum in California; and

2,100 tons, valued at $14.16 per ton, were produced in Texas. If 4 per cent of this material were used as a binder, the cost per ton of briquets produced would be 45 to 55 cents per ton, making this binder one of the cheapest to be had near the oil fields, when the oil contains an asphalt base. Even less than 4 per cent could be used with some coals. For the best results, the asphalt residue should flow at 90° to 100° C.

Six samples of asphalts were examined. The sample designated 37 A was shown by test to flow at 100° C., and 99.38 per cent was soluble in carbon disulphide. The tests showed that except with the lignites, 3 to 4 per cent of this asphalt would give a satisfactory briquet. With caking coals it is satisfactory in the fire.

Another sample was designated 37 B. With most coals 3 to 4 per cent of this asphalt would be required to produce satisfactory briquets.

The sample designated 37 C was received through Dr. Pratt from Caspar, Wyo., and by him was designated B 6 in his report.[a] It flowed at 95° C., and gave a carbon-disulphide extract of 99.88 per cent. A satisfactory briquet was made with 4 per cent of this binder.

The sample designated 37 D was received from Texas, and was designated B 3 in Dr. Pratt's report.[a] It flowed at 140° C., and with most coals about 6 per cent would be required to produce a satisfactory briquet.

The sample designated 37 E, a California asphalt of grade B, was designated B 1 by Dr. Pratt.[a] It did not soften sufficiently at 100° C., but if superheated a satisfactory briquet could be obtained with 8 per cent as binder.

The sample designated 37 F, a Texas asphalt, was designated B 2 by Dr. Pratt.[a] It did not soften sufficiently at 100° C. When superheated it gave a satisfactory briquet with Illinois No. 4 coal, 6 per cent of binder being used.

38. *Water-gas tar.*—The census report states that 75 per cent of the illuminating gas produced in the United States in 1899 was water gas. Petroleum oil is used in enriching this gas and is partly decomposed in the process, resulting in the formation of water-gas tar, of which 48,714,324 gallons were produced in 1899. With an average density of 1.1, this would be equivalent to 222,868 tons of tar. The tar itself is too liquid for use, but a pitch made from it was examined, as shown in the next paragraph.

39. *Water-gas tar pitch.*—The sample of water-gas tar pitch furnished to Dr. Pratt was by him designated pitch H.[a] It flows at 92° C., and with some of the coals 5 per cent proved sufficient to produce excellent briquets. The carbon-disulphide extract was 88.10 per cent. With caking coals the briquets are satisfactory in the fire. This pitch is worth somewhat less than coal-tar pitch, its value being

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[a] Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; Bull. U. S. Geol. Survey No. 261, 1905, p. 134.

given approximately as $10 per ton. The cost of the binder per ton of briquets produced would therefore be about 50 cents, effecting a saving of at least 20 cents per ton over the use of ordinary coal-tar pitch.

40. *Wax tailings.*—A product known as wax tailings was received by Dr. Pratt. It is soft at ordinary temperatures and pulls into long threads. It melts to a thin liquid at about 70° C. As low as 3 per cent gives briquets of satisfactory coherence and these are also satisfactory in the fire if the coal cakes readily. The briquets could not be subjected to any pressure in the fire, and would yield to pressure if placed in a warm place. It is doubtful if they could be piled in a very hot sun. The yield of this product is said to be moderate in amount. The value is 6 cents per gallon, or about $15 per ton, and the cost of this binder would therefore be 45 to 60 cents per ton of briquets produced.

41. *Acid sludge.*—Tests of a sample of acid sludge showed that 10 to 12 per cent was necessary to make a coherent briquet. This material was distinctly acid with sulphuric acid. Its value could not be learned and therefore no further experiments were tried with it.

42. *Asphalt tar.*—The product known as asphalt tar, as obtained by Dr. Pratt, was a rather thin liquid which poured readily and produced briquets that would crush easily and would not stand up satisfactorily in the fire. This tar, if its price permitted, might be used for waterproofing briquets made with soluble binders, as starch, sulphite liquor, or molasses.

43. *Pintsch gas tar.*—Pintsch gas tar, produced by the heating of petroleum oil in iron retorts to a high temperature, is obtained as a thin emulsion in water, being too thin for use as a binder. As it is produced only in very small amounts in the United States, its further examination was deemed inadvisable.

44. *Pittsburg flux.*—The substance known as Pittsburg flux is made by heating petroleum residuum with sulphur. The sample tested was tough and sticky, would cut easily, but would not pull into threads. It melted to a thin liquid at about 195° C. In testing it was mixed with Illinois No. 11 C (4) coal and heated far above 100° C. It produced a satisfactory briquet when 8 per cent was used.

ADDITIONAL EXPERIMENTS WITH MIXTURES.

All the briquets made with inorganic binders were brittle, though very hard. Experiment had shown that when brittle pitches, etc., were used, the briquets became less brittle if a thinner pitch or oil was added. Therefore an attempt was made to improve these briquets by the addition of organic binders. For this purpose coal-tar creosote (27), asphalt tar (42), and water-gas tar pitch (39) were chosen. The results are shown in the following table:

Results of briquetting California and Illinois coals with varying mixtures of organic and inorganic binders.

Coal.	Binder.				Grade of coherence.[a]
	Inorganic constituent.		Organic constituent.		
	Material.	Per cent.	Material.	Per cent.	
Illinois No. 6 B	Plaster of Paris	6	Coal-tar creosote	4	3
	....do	6	Asphalt tar	4	4
	....do	6	Water-gas tar pitch	4	4
	Portland cement	6	Coal-tar creosote	4	3
	....do	6	Asphalt tar	4	3
	....do	6	Water-gas tar pitch	4	4
	Magnesium oxide	2	Coal-tar creosote	4	3
	....do	2	Asphalt tar	4	3
	....do	2	Water-gas tar pitch	4	3½
California No. 1	Plaster of Paris	6	.....do	8	4½
	Portland cement	6	.....do	8	4½
	Magnesium oxide	3	.....do	8	4
	....do	4	.....do	4	3

[a] See p. 22.

The briquets made with Illinois coal and water-gas tar pitch were fairly good and stood up very satisfactorily in the fire. The advantage gained, however, over the use of the water-gas tar pitch alone would not be sufficient to offset the introduction of the 6 per cent of ash with the cement or the plaster of Paris, or the cost of the magnesium oxide when that material is used. The cohesive force of the briquets made with the two binders was no greater than the sum of the cohesive force obtained with each separately. The only advantage to be gained by using such mixed binders would be an added strength in the fire. Experiments with the California lignite were therefore made as above shown. The briquets were found to be considerably improved as to their behavior in the fire by the addition of the inorganic constituent of the binder. Briquets from this coal made with pitch alone fall to pieces badly in the fire. The improvement in this regard, however, is offset by the added expense and the introduction of ash, and it is therefore considered more desirable where possible to mix such noncaking coals with caking coals before briquetting. If this is not practicable then the addition of inorganic binders might be tried as a last resort. Should the inorganic binders be used, magnesium oxide and plaster of Paris will be found to give the most satisfactory results, 3 per cent of the former being equivalent to 5 to 6 per cent of the latter.

EXPERIMENTS IN BRIQUETTING WITHOUT BINDERS.

Many experiments were made in the endeavor to obtain briquets by heating the coal without binder and then pressing. It was found that if this heating was done in a clay crucible as usual, coherent briquets could not be obtained. But if the heating was done in a small nickel crucible and the pressure applied before the coal was allowed to cool, briquets having considerable coherence were often produced. If the coal cooled after it had softened or commenced to cake, a coherent briquet could not be obtained, and even on again heating the coal it would not cohere in the press. This fact has also been noted by C. C. Catlett.[a] It was undoubtedly because of the necessary chilling of the heated coal in taking it out of the crucible that better results were not obtained by this method. The experiments show the necessity of heating the coal under pressure if briquets are to be made without a binder. The German presses for briquetting lignite coal without a binder, which heat the coal by friction produced in the molds, are undoubtedly based on the right principle.

RESULTS OF TESTS IN BRIQUETTING DIFFERENT COALS.

The results of the tests here reported should be interpreted in connection with the detailed discussion of each binder. Thus while binders 12 D, 13, 25, 26, etc., mentioned in the table which follows, are too liquid for use as a binder, the pitches or tarry residues left after distilling off the low-boiling oils from these binders will make excellent briquets, as has been already pointed out. It should be remembered, moreover, that the degree of fineness to which the coal is powdered, and also the temperature to which the mixture of coal and binder is heated, will affect the character of the briquet and the percentage of binder necessary to make it coherent. Doubtless an uncontrolled variation in these factors has caused individual results to vary, but probably not to such an extent as to affect any important conclusions to be drawn from the work.

Although many of the binders were tried with only one coal, the result permits the approximate prediction of the percentage of binder for any other coal in the table. It is not possible, however, to predict with the same certainty for the lignites, which show at times variations not susceptible of easy explanation.

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[a] Eng. and Min. Jour., vol. 71, 1901, p. 329.

Results of tests in briquetting different coals, showing percentages of binder necessary to make a satisfactory briquet.

Designation of binder.		Field designation of coals and lignites briquetted.											
					Illinois.								
Material.[a]	No.	Arkansas. 7 A?.	California. 1.	Colorado. 1.	4.	5.	6 B.	7 C.	7 D.	8.	9 A.	10.	11 B.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Clay	1	8	8				8						8
Magnesia,	3	4					5						4
Magnesia cement[b]	4												4
Plaster of paris	5												12
Portland cement	6												12
Natural cement	7												14
Water glass	9												14
Rosin	10	6	6				6						6
Pitch	11	3	5				4						3.5
Wood-tar pitch	12 A	8	12				12						10
Pine-wood tars	12 B	3	8				4	3		5	5	4	3.5
	12 C	4	9				5	4		5	5	5	4.5
	12 E						6						
Fir tar	14						6						
Sulphite liquor	16		12				10						
Cornstarch	21	0.5	1	1			1						0.75
Potato starch	22	.5	1	1			1						.75
Producer-gas tar pitch.	24 C				4								
Producer-gas tar	24 D	4											
Coal-tar pitches	28 A	6					7						7
	28 B	8	16		12	8							
	28 C	6.5											
	28 D	6.5			8								
	28 E				7								
	28 F				8								
	28 G				6								
	28 H				6								
	28 I	14		20			16	14		16	16	16	15
	28 J			16			12	10		12	12	11	11
Maltha	32				3								
Petroleum residuums	37 A	3	6				4						4
	37 C	3.5					4						4
	37 D				6								
	37 E				7								
	37 F				6								
Water-gas tar pitch	39	4.5	8		6.5		6	5	6	6.5	6.5	6	5
Wax tailings	40	3					4						3
Acid sludge	41	12	14				14						14

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[a] The following materials were found to be of no use as binders: Lime (2), slag cement (8), wood pulp (15), beet pulp (17), lime cake (18), and impsonite (30). Those found to be too liquid for use as binder were: Pine-wood tar (12 D), pine-wood creosote (12 F), hard-wood tar (13), illuminating-gas tar (25), by-product coke-oven tar (26), coal-tar creosote (27), crude oil (36), water-gas tar (38), asphalt tar (42), and Pintsch gas tar (43). Satisfactory briquets were not obtained from beet-sugar molasses (19) and cane-sugar molasses (20). Blast-furnace tar is not produced in the United States.

[b] Contained sufficient magnesia to make 4 per cent MgO

Results of tests in briquetting different coals, showing percentages of binder necessary to make a satisfactory briquet—Continued.

Designation of binder.		Field designation of coals and lignites briquetted.										
Material.	No.	Illinois. 11 C (4).	Illinois. 14.	Indian Territory. 6.	Iowa. 2.	Missouri. 3.	New Mexico. 1.	New Mexico. 2.	North Dakota. 1.	Oklahoma.	West Virginia. 7.	West Virginia. 9.
1	2	15	16	17	18	19	20	21	22	23	24	25
Clay	1	8						8				
Magnesia	3	5						5				
Rosin	10	6						6				
Pitch	11	3.5						3.5				
Wood-tar pitch	12 A	12						12				
Pine-wood tars	12 B	5	6					6	10			
	12 C	5	6									
Cornstarch	21	1					1	1		1.5		
Potato starch	22	1					1	1		1.5		
Producer-gas tar	24 D	6										
Coal-tar pitches	28 A	7										
	28 B			8	8	8	14	8	16	10	8	10
	28 I					16			24			
	28 J								18			
Gilsonite	31 A	4										
	31 B	6										
Refined asphalt	....	6										
	....	8										
Petroleum residuums	37 A	4						6				
	37 B	4										
	37 C	4										
Water-gas tar pitch	39	6	6.5									
Wax tailings	40	4										
Acid sludge	41	14										
Pittsburg flux	44	8										

BIBLIOGRAPHY.

SURVEY PUBLICATIONS ON BRIQUETTING.

The following reports (except the first two) can be obtained by application to the Director of the United States Geological Survey, Washington, D. C.:

Bulletin No. 261. Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. 1905. 172 pp. Can be obtained by sending 10 cents in cash to the Superintendent of Documents, Washington, D. C.

Professional Paper No. 48. Report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. E. W. Parker, J. A. Holmes, M. R. Campbell, committee in charge. 1906. In three parts. 1492 pp., 13 pls. Can be obtained by sending $1.50 in cash to the Superintendent of Documents, Washington, D. C.

Bulletin No. 290. Preliminary report on the operations of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905. J. A. Holmes, in charge. 1906. 240 pp.

Bulletin No. 316. Contributions to economic geology, 1906, Pt. II. M. R. Campbell, in charge. Separate containing papers on producer-gas power plants, coal briquetting, and coal-mine sampling. pp. 439–532.

Bulletin No. 332. Report of the United States fuel-testing plant at St. Louis, Mo., January 1, 1906, to June 30, 1907. J. A. Holmes, in charge. 299 pp.

MISCELLANEOUS PUBLICATIONS.

The following references are supplementary to the "Partial bibliography of briquetting" in Survey Bulletin No. 290, pp. 48–51:

Special Consular Reports, vol. 26. Briquets as fuel in foreign countries.

Daily Consular and Trade Reports, December 27, 1905. The briquet industry.

Daily Consular Reports, May 27, 1905. New fuel from petroleum.

Daily Consular and Trade Reports, May 28, 1906. Pressed-coal works combine to control prices.

Daily Consular and Trade Reports, November 5, 1906. Belgian briquets.

Daily Consular and Trade Reports, April 4, 1906. Brazilian coal. Government will erect briquet plant.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 344

THE
STRENGTH OF CONCRETE BEAMS

RESULTS OF TESTS OF 108 BEAMS
(FIRST SERIES)

MADE AT THE STRUCTURAL-MATERIALS
TESTING LABORATORIES

BY RICHARD L. HUMPHREY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

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THE STRENGTH OF CONCRETE BEAMS.

By Richard L. Humphrey.

INTRODUCTION.

SCOPE OF INVESTIGATIONS.

The tests of concrete beams described in this bulletin form a part of a comprehensive series of investigations undertaken by the United States Geological Survey for the purpose of determining the strength of concrete and reinforced concrete.

The work involved in these investigations consists of a study (1) of the constituent materials of concrete, (2) of its strength when molded into various structural shapes, and (3) of the methods by which its maximum strength may be developed through various forms of metallic reinforcement.

Although it is true that concrete possesses but little strength in tension and must be reinforced with metal to resist tensile stresses, it is believed that no study of concrete would be complete without a series of tests establishing its strength without reinforcement.

The tests herein reported indicate that concrete is unsuitable for use under conditions where it must resist tensile stresses, because of the small loads it will sustain and particularly because of the suddenness with which it fails, in striking contrast to the behavior of reinforced concrete, which usually shows a gradual development of cracks preceding failure.

This first series of beam tests covers 144 beams without reinforcement 8 by 11 inches in section and 13 feet long, together with the corresponding compression test pieces, consisting of cylinders 8 inches in diameter by 16 inches in length and of 6-inch cubes. Of these tests those on 108 beams of 12-foot span, with their cylinders and cubes, and those on 108 beams of variable spans, 6 to 9 feet, which were made of the larger part of the 13-foot beams after rupture, are herein reported and comprise all of this series except the 52-week tests.

An attempt has been made to bring out, if possible, the comparative value of gravel, granite, limestone, and cinders for use in concrete; the effect of age and consistency on the strength, as shown by the modulus of rupture of the long and short beams and by the ultimate strength of the cylinders and cubes; and the influence of age and consistency on the stiffness, which is indicated by the unit elongation of the long and short beams and by the initial modulus of elasticity, as determined by tests of the cylinders.

Three consistencies — wet, medium, and damp — were somewhat arbitrarily chosen, and are described on pages 20–21 in greater detail. Tests were made at the ages of 4, 13, 26, and 52 weeks. There are, then, as indicated in the following table, but two variables—aggregate and consistency—for each age.

Outline of tests of concrete beams.

Aggregate.	Consistency.											
	4 weeks.			13 weeks.			26 weeks.			52 weeks.		
Granite	Wet.	Med.	Damp.	Wet.	Med.	Damp.	Wet.	Med.	Damp.	Wet.	Med.	Damp.
Gravel	do	do	do	do	do	do	do	do	do	do	do	do
Limestone	do	do	do	do	do	do	do	do	do	do	do	do
Cinders	do	do	do	do	do	do	do	do	do	do	do	do

NOTE.—Three beams, three cylinders, and three cubes were made for each variation shown in the table.

METHODS OF TESTING.

The methods of testing beams of 12-foot and variable spans, together with cylinders and cubes, have been described in considerable detail in Bulletin No. 329. It is thought best, however, to repeat and in some cases amplify matter which appears there, as the intelligent interpretation of much of the test data is greatly aided by ready access to an account of the methods of testing that were used.

RESULTS OF TESTS.

No attempt has been made in this bulletin to generalize the results of the tests herein presented, or to draw any conclusions, however warranted they may appear from an examination of the test data. It is hoped that the matter herein contained will provoke discussion, and in order to promote this end extended expressions of opinion or attempted applications of theory to results have been avoided. A running commentary on the results of the tests, however, emphasizing matters of particular interest and indicating a few points that might lead to interesting analyses, is included in this report. When the results of the 52-week tests become available it is the intention to publish a thorough analysis of the entire series in another bulletin.

The purpose of this series of tests was to determine—

(1) The effect of age on the strength of concrete;

(2) The effect of variation in the consistency on the strength of concrete; and

(3) The effect of different types of aggregates on the strength of concrete.

The first question is perhaps the most important, since an early attainment of considerable strength and no subsequent decrease in strength are two essential qualities in concrete, in order that a structure may be put to the use for which it is intended as soon as possible and that there shall be no subsequent deterioration in strength.

The least age at which any tests were made was four weeks, and at that period in no case except that of the cinder concrete, wet consistency, did the compressive strength fall below 2,000 pounds per square inch, while the cinder concrete had in every case a compressive strength of at least 1,000 pounds per square inch.

In every instance the compressive strength shows a substantial increase from four to thirteen weeks, with the single exception of limestone concrete mixed to a wet consistency, for which a decreased strength is indicated by the tests, a decrease which continues to the age of twenty-six weeks. This decrease in the strength of the limestone concrete is unexplainable, and the results of the 52-week tests on this material will be of value as indicating whether or not this decrease continues to the latter period. The other aggregates show either the same or a slightly greater strength at twenty-six weeks than at thirteen weeks.

The transverse tests on both the long and the short beams bear out very closely the fact indicated by the compression tests on the cylinders and cubes, and lead to the belief that the tensile and compressive strength are affected alike by both age and consistency. The effect on the strength of the variation in the consistency is clearly shown. In almost every case the concrete of the damp consistency is the strongest and that of the wet consistency the weakest. This is true for the three ages at which the concrete was tested, and is confirmed by the tests of the beams as well as of the cylinders and the cubes. Attention is called to the fact that the damp consistency used is much wetter than the damp consistency used in making mortar building blocks, for which the same conclusions may not apply.

The difference in strength of the stone and gravel concretes of the three consistencies is more pronounced than in the case of the cinder concrete. The effect of the consistency on the strength seems to depend to a great extent on the behavior of the concrete while being tamped and to the method used in tamping. Great care was taken to tamp all the concretes in the same manner. The thorough mixing of the concrete is absolutely essential and has a marked influence on the consistency.

The relatively slight influence exerted by the consistency on the strength of cinder concrete may be partly due to the structural weakness of the cinders themselves, which in the drier mixtures were to a great extent broken up by the tamper, while in the wet mixtures, the cinders would move from beneath the tamper.

While it is true that in almost every instance the drier mixtures give the greater strength, it does not follow that dry (or damp) mixtures should be used in construction. Practical considerations warrant the use of a wet mixture. The difficulty in securing efficient tamping and a smooth finish in a damp concrete, the loss of strength due to the unavoidable drying out of the concrete used above water, the difficulty of securing in reinforced concrete an intimate union with the steel, and the far greater ease of placing wet concrete all seem to warrant the sacrifice of what in many cases is but a slight difference in strength for a greater ease of manipulation and a thorough bedding of the steel, which is of the utmost importance in reinforced concrete work.

It is dangerous to draw any general conclusions as to the relative value of concrete made of the four aggregates used unless the character of the aggregates used in this particular series of tests is carefully kept in mind. The gravel, granite, limestone, and cinders were used as available representative types of aggregates, and while the results indicate that the granite makes the strongest concrete, it should not be assumed, therefore, that a granite concrete is stronger than a gravel, limestone, or cinder concrete. Every material should be accepted or rejected on the results of the tests of its qualities, regardless of the tests of other materials of the same type. Apparently insignificant differences in two materials which appear to be similar often cause considerable difference in the strength of concrete made from them. For instance, two limestones from the same quarry crushed and screened under similar conditions—except that one was screened while wet, which caused the dust to adhere to the surface of the stone—would make concretes of considerable difference in strength.

Because the hard, flinty gravel used in these tests gave excellent results, it does not necessarily follow that a similar well-graded gravel, but composed of soft limestone or shale, would give like results. No series of investigations, however elaborate, will do away with the necessity of careful inspection of the materials to be used. The relative value of materials reported in this bulletin should be recognized, therefore, as applicable only to the particular materials from which the reported physical properties were obtained.

ACKNOWLEDGMENTS.

All the material used in the tests herein reported was donated by the following companies, who deserve credit for their interest and hearty cooperation in advancing the work:

Cement.—Iola Portland Cement Company, Iola, Kans.
Atlas Portland Cement Company, Hannibal, Mo.
Whitehall Portland Cement Company, Cementon, Pa.
Universal Portland Cement Company, Chicago, Ill.
Edison Portland Cement Company, New Village, N. J.
Omega Portland Cement Company, Mosherville, Mich.

Old Dominion Portland Cement Company, Fordwick, Va.
Lehigh Portland Cement Company, Mitchell, Ind.
St. Louis Portland Cement Company, St. Louis, Mo.

Sand.—Union Sand and Material Company, St. Louis, Mo. A recent river sand dredged from Meramec River at Drake, Mo.

Gravel.—Union Sand and Material Company, St. Louis, Mo. A recent river gravel dredged from Meramec River at Drake, Mo.

Granite.—Schneider Granite Company, St. Louis, Mo. A hard, red granite quarried near Graniteville, Mo.

Cinders.—United Railways Company, St. Louis, Mo. These cinders were obtained from the Dehodiamont power house, St. Louis, and gave better results than those selected from other sources.

Limestone.—Fruin-Bambrick Construction Company, St. Louis, Mo. Obtained from a quarry in St. Louis.

The tests were supervised by Louis H. Losse, and the results were computed and collated by Harry Kaplan.

TESTS OF CONSTITUENT MATERIALS.

CEMENT.

PREPARATION OF TYPICAL CEMENT.

The cement used in all the tests in these laboratories is known as typical Portland cement. It is prepared by thoroughly mixing together a number of Portland cements. The method of preparing the typical Portland cement that was used in the tests herein reported and in the tests on the second and third series, reinforced beams, including in all 576 beams, cylinders, and cubes, was as follows:

One thousand eight hundred sacks of cement, 200 from each of nine companies, were used. Two hundred sacks of one brand were spread over a concrete floor 25 by 40 feet in area and thoroughly mixed by hoeing from side to side. Two samples were then taken, a 50-pound sample for tests to be made by the constituent-materials section, and a smaller one for chemical tests. The cement was then resacked. When all the brands had been separately mixed in this way, two sacks of each brand were spread on the floor in a layer about 3 inches thick. One brand was spread upon another in blanket form, making nine separate layers of cement for the nine brands used. The mass was mixed very carefully with shovels until a uniform mixture was obtained. A 10-pound sample was taken for physical tests and the cement was sealed in air-tight cans, two cans of 800 pounds capacity each being required to hold one mix.

RESULTS OF TESTS.

Table 1 contains the results of the chemical tests of the individual brands, made on samples taken as indicated above. The average of the columns may be taken as the analysis of the typical Portland cement.

TABLE 1.—*Chemical analyses of individual brands used in the preparation of typical Portland cement.*

Cement No.	Silica (SiO_2).	Alumina (Al_2O_3).	Ferric oxide (Fe_2O_3).	Lime (CaO).	Magnesia (MgO).	Sulphuric anhydride (SO_3).	Water (H_2O).	Ignition loss.	Undetermined.
200	20.34	9.36	3.04	63.40	1.35	1.47	....	....	1.04
201	22.12	6.50	3.22	61.39	2.58	1.89	0.94	0.55	.97
202	20.96	8.08	2.80	62.68	1.45	1.54	.18	1.61	.70
203	20.52	8.54	2.68	62.47	1.92	1.50	.29	1.43	.65
204	20.04	7.70	2.74	63.26	2.24	1.56	.08	.96	1.60
205	22.04	9.50	1.42	61.46	1.68	1.58	.55	.84	.93
206	22.80	9.56	1.06	61.04	1.37	1.82	.64	.77	.94
207	22.96	9.34	1.32	61.20	1.47	1.81	.28	.86	.76
208	23.48	8.22	1.80	61.10	1.62	1.68	.44	.81	.85
Average	21.70	8.53	2.23	62.00	1.74	1.67	.43	.98	.94

Table 2 contains the results of the physical tests, except those for strength of the individual brands. All these tests were made according to the methods recommended by the special committee on uniform tests of cement of the American Society of Civil Engineers.

TABLE 2.—*Physical tests of individual brands used in typical Portland cement.*[a]

Cement No.	Residue on sieve (per cent)—		Specific gravity.	Water (per cent).	Time of set (minutes).				Normal pat tests.	
					Vicat.		Gilmore.			
	100.	200.			Initial.	Final.	Initial.	Final.	Air (70° F.).	Water (70° F.).
200	5 9	20.9	3.136	21.0	184	340	155	325	Normal	Normal.
201	5.5	22.1	3.058	20.5	93	378	110	486	do	Do.
202	7.8	24.6	3.121	20.5	138	329	152	393	do	Do.
203	4.4	20.6	3.099	21.5	117	315	150	352	Crack 1" long ¼" from edge.	Do.
204	2.0	12.0	3.087	24.0	124	416	229	458	Normal	Do.
205	6.0	22.2	3.165	21.0	127	370	178	394	Warped 1/32" from edge.	Do.
206	5.3	21.5	3.127	21.0	113	338	195	441	Normal	Do.
207	6.0	23.2	3.129	20.5	146	391	182	372	do	Do.
208	3.1	21.6	3.141	22.5	170	332	217	400	do	Do.
Average	5.1	21.0	3.108	21.4	135	357	174	402		

[a] In the accelerated pat tests, in water at 212° F. for 3 hours and in steam maintained at normal pressure for 5 hours, the results were normal in each case for each brand of cement.

Table 3 contains the results of the strength tests of the individual brands. Tests were made for both neat cement and 1:3 mortar with Ottawa sand, in tension, compression on 2-inch cubes, and modulus of rupture on a 1 by 1 inch prism tested by a center load on a 12-inch span. All tests were made according to the methods recommended by the special committee on uniform tests of cement of the American Society of Civil Engineers.

TABLE 3.—*Strength tests of individual brands used in the preparation of typical Portland cement.*

Cement No.	Temperature (°F.).				Water (per cent).	Strength of neat test pieces (pounds per square inch).														
						Tensile.					Compressive.					Transverse.				
	Air.	Water.	Closet	Tanks.		1 day.	7 days.	28 days.	90 days.	180 days.	1 day.	7 days.	28 days.	90 days.	180 days.	1 day.	7 days.	28 days.	90 days.	180 days.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
200	64.4	68.0	64.4	53.6	21.0	332	655	864	859	886	2,375	10,090	11,130	12,918	17,820	702	1,962	2,088	2,070	2,070
						324	698	870	842	878	2,500	9,225	11,310	13,200	18,172	828	1,800	1,998	2,124	2,124
						332	672	852	846	859	2,400	10,925	10,060	13,270	16,542	792	1,980	2,124	2,196	2,232
Average						329	675	862	849	874	2,425	10,080	10,833	13,129	17.511	774	1,914	2,070	2,130	2,142
201	68.8	68.0	61.4	70.0	20.5	144	616	772	835	880	1,425	5,895	8,100	11,520	11,450	396	1,224	1,674	2,016	1,980
						172	601	729	886	861	1,400	5,638	8,655	12,225	11,038	414	1,260	1,548	1,980	1,944
						171	......	728	842	848	....	5,088	8,022	11,965	11,350	......	1,278	1,710	2,061	1,908
Average						162	608	743	854	863	1,413	5,540	8,259	11,903	11,279	405	1,254	1,644	2,019	1,944
202	64.4	68.0	64.4	68.9	20.5	401	754	792	842	832	3,900	7,500	9,250	12,272	13,825	702	1,692	1,764	1,962	1,926
						475	725	776	803	881	3,750	8,125	9,775	11,905	14,060	702	1,584	1,728	2,034	1,836
						487	760	780	832	870	4,025	....	9,300	12,050	14,187	648	1,728	1,836	1,935	1,980
Average						454	746	783	826	861	3,892	7,813	9,442	12,076	14,024	684	1,668	1,776	1,977	1,914
203	66.4	68.0	68.9	73.4	21.5	299	562	781	827	840	2,400	6,778	9,425	11,525	13,525	792	1,296	1,728	1,971	2.052
						312	585	814	886	835	1,625	7,300	8,867	11,312	14,028	774	1,260	1,908	1,908	1,980
						292	548	809	881	854	2,125	6,990	8,880	12,022	13,842	972	1,404	1,836	1,980	2,124
Average						301	565	801	865	843	2,050	7,023	9,057	11,620	13,798	846	1,320	1,824	1,953	2,052
204	68.0	68.0	66.2	71.6	24.0	276	622	715	790	835	2,325	6,675	9,200	11,457	14,025	558	1,368	1,710	1,926	2,088
						285	640	712	815	837	2,200	6,055	8,125	11,225	13,062	576	1,368	1,656	1,908	2,052
						275	623	732	821	826	2,225	6,195	8,475	....	13,705	558	1,296	1,602	1,890	2,016
Average						279	628	720	809	833	2,250	6,308	8,600	11,341	13,597	564	1,344	1,656	1,908	2,052
205	72.0	68.0	71.6	74.3	21.0	305	638	790	820	855	2,075	6,550	10,125	11,800	13,655	684	1,350	2,052	1,976	2,124
						308	616	762	811	862	1,975	7,050	9,675	12,155	13,972	720	1,476	2,120	1,926	1,980
						326	620	806	809	888	2,000	7,175	9,475	11,450	14,137	702	1,386	1,962	2,052	1,998
Average						313	625	786	813	868	2,017	6,925	9,758	11,802	13,921	702	1,404	2,045	1,985	2,034
206	70.0	68.0	71.6	69.8	21.0	452	576	758	809	770	3,500	6,625	9,370	11,465	14,377	882	1,584	1,494	1,710	2,088
						434	548	735	827	810	3,225	6,975	9,550	11,750	13,747	882	1,548	1,656	1,836	2,016
						438	578	742	851	775	3,400	7,300	9,655	11,505	13,712	936	1,602	1,557	1,809	2,124
Average						441	567	745	829	785	3,375	6,967	9,525	11,573	13,945	900	1,578	1,569	1,785	2,076

TABLE 3.—*Strength tests of individual brands used in the preparation of typical Portland cement*—Continued.

Cement No.	Temperature (F°.).				Water (per cent).	Strength of neat test pieces (pounds per square inch).														
	Air.	Water.	Closet.	Tanks.		Tensile.					Compressive.					Transverse.				
						1 day.	7 days.	28 days.	90 days.	180 days.	1 day.	7 days.	28 days.	90 days.	180 days.	1 day.	7 days.	28 days.	90 days.	180 days.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
207	73.0	64.4	69.8	66.2	20.5	375	685	827	798	820	3,550	8,425	9,698	14,037	13,817	990	1,530	1,926	1,800	1,962
						375	720	825	810	800	3,800	8,000	10,228	12,583	13,722	846	1,494	1,823	1,827	1,980
						358	692	788	793	804	3,700	8,300	10,275	13,325	14,200	972	1,494	1,962	1,728	1,998
Average						369	699	813	800	808	3,683	8,242	10,067	13,320	13,913	936	1,506	1,904	1,785	1,980
208	66.2	68.0	69.8	65.3	22.5	326	820	748	810	825	3,675	7,375	9,668	10,798	14,050	864	1,728	1,566	2,106	1,998
						355	792	762	807	828	3,350	7,975	9,000	11,347	13,797	954	1,512	1,620	1,960	2,052
						342	784	750	814	835	3,575	7,625	9,300			936	1,620	1,544	2,021	1,980
Average						341	799	753	810	829	3,533	7,658	9,323	11,070	13,923	918	1,620	1,577	2,036	2,010
Grand average					21.4	336	659	778	828	840	2,789	7,379	9,429	12,044	13,993	761	1,512	1,674	1,953	2,023

Cement No.	Temperature (°F.).				Water (per cent).	Strength of 1:3 standard-sand mortar test pieces (pounds per square inch).											
	Air.	Water.	Closet.	Tanks.		Tensile.				Compressive.				Transverse.			
						7 days.	28 days.	90 days.	180 days.	7 days.	28 days.	90 days.	180 days.	7 days.	28 days.	90 days.	180 days.
1	2	3	4	5	22	23	24	25	26	27	28	29	30	31	32	33	34
200	64.4	68.0	64.4	53.6	8.9	364	425	426	515	3,025	5.000	4,175	4,787	720	792	846	990
						375	419	461	510	2,475	4,575	4,300	5,363	630	810	936	972
						395	413	445	486	3,325	5,125	4,200	5,150			864	
Average						378	419	444	504	2,942	4,900	4,225	5,100	675	801	882	981
201	68.8	68.0	61.4	70.0	8.9	171	290	412	421	1,450	2,225	3,000	3,175	342	576	828	756
						156	330	410	454	1,475	2,225	3,050	3,300	378	576	819	810
						194	320	428	430	1,375	2,350	2,925	3,250	288	612	864	
Average						174	313	417	435	1,433	2,267	2,992	3,242	336	588	837	783
202	64.4	68.0	64.4	68.9	8.9	335	425	408	430	2,696	4,000	4,525	3,800	648	882	972	918
						320	457	439	478	2,472	4,375	4,425	3,925	684	954	932	972
						328	435	445	464	2,875	4,250	4,650	3,775				
Average						328	439	431	457	2,681	4,208	4,400	3,833	666	918	952	945

203	66.4	68.0	68.9	73.4	9.1	265	355	431	452	1,700	3,667	4,000	4,400	612	828	684	972
						272	411	446	445	1,775	3,875	4,225	4,225	540	774	738	918
						275	362	443	456	1,650	3,450	4,125	4,100	558	684	720	....
Average	....	....	....	....	....	271	376	440	451	1,708	3,664	4,117	4,242	570	762	714	945
204	68.0	68.0	66.2	71.6	9.5	363	420	495	475	2,100	3,550	3,900	4,325	540	810	936	1,008
						322	406	472	450	1,975	3,425	3,800	4,450	540	810	918	891
						330	394	466	460	2,150	3,725	3,500	4,225	540	....	....	....
Average	....	....	....	....	....	338	407	478	462	2,075	3,567	3,733	4,333	540	810	927	950
205	72.0	68.0	71.6	74.3	9.0	247	401	446	482	1,625	2,975	3,925	4,375	450	828	1,026	1,008
						219	424	430	465	1,775	2,750	3,850	4,500	504	918	972	972
						220	387	449	460	1,625	3,000	3,800	4,625	576	940	954	....
Average	....	....	....	....	....	229	404	442	469	1,675	2,908	3,858	4,500	510	895	984	990
206	70.0	68.0	71.6	69.8	9.0	284	406	450	465	2,100	3,625	3,325	4,450	738	873	972	756
						281	445	436	493	2,100	3,325	3,175	4,400	648	918	900	783
						272	....	493	468	2,075	3,425	3,125	4,625	720	837	914	774
Average	....	....	....	....	....	279	426	460	475	2,092	3,458	3,208	4,492	702	876	929	771
207	73.0	64.4	69.8	66.2	8.9	324	455	488	445	1,900	3,425	4,425	4,975	720	972	990	702
						330	418	476	438	2,100	3,550	4,400	4,900	666	999	936	720
						358	464	452	450	2,250	3,650	4,275	4,950	666	1,026	936	720
Average	....	....	....	....	....	337	446	472	444	2,083	3,542	4,367	4,942	684	999	954	714
208	66.2	68.0	69.8	65.3	9.3	327	427	535	496	2,225	3,750	4,162	4,225	720	1,539	1,008	684
						330	472	509	521	2,350	3,500	4,750	4,575	738	1,566	985	702
						291	462	530	526	2,200	3,650	....	4,400	666	1,566	1,026	756
Average	....	....	....	....	....	316	454	525	514	2,258	3,633	4,460	4,400	708	1,557	1,006	714
Grand average	....	....	....	....	9.1	294	409	457	468	2,105	3,572	3,905	4,343	593	920	907	847

TABLE 4.—*Physical properties of cements used in concrete beams.*

Register No.	Specific gravity.	Temperature (°F.).		Water (per cent).	Time of set (minutes).				Residue on sieve (per cent)—		Tensile strength of neat cement (pounds per square inch).					Soundness (as indicated by appearance of pat).
		Water.	Air.		Vicat.		Gilmore.		100.	200	1 day.	7 days.	28 days.	90 days.	180 days.	
					Initial.	Final.	Initial.	Final.								
209	3.112	75.2	71.6	21.0	138	370	180	403	4.8	19.8	422	696	841	704	836	Pat A, warped $\frac{1}{32}$ inch around edge.
210	3.116	75.2	71.6	21.0	137	372	239	429	4.6	20.8	468	698	816	714	836	Normal.
211	3.111	75.2	71.6	21.0	132	386	226	401	5.0	22.4	496	678	828	757	843	Pat D, warped $\frac{1}{32}$ inch around edge.
213	3.111	74.0	70.6	21.0	180	389	275	430	5.2	20.8	451	687	799	792	857	Pat C, warped $\frac{1}{32}$ inch around edge.
214	3.116	74.0	70.6	21.0	195	379	262	410	5.0	21.8	470	758	848	769	851	Normal.
218	3.108	75.0	71.6	21.0	200	443	192	475	4.9	21.3	373	770	769	812	829	Do.
219	3.113	75.0	71.6	21.0	195	432	275	470	4.8	20.7	371	793	785	798	822	Do.
220	3.112	77.0	65.0	21.0	222	446	279	512	5.0	20.8	382	757	765	795	833	Do.
223	3.113	73.0	68.0	21.0	174	435	245	472	4.6	21.2	368	723	791	801	821	Do.
224	3.114	73.0	68.0	21.0	192	415	250	474	4.7	21.1	425	760	758	816	840	Do.
225	3.118	73.0	68.0	21.0	182	419	242	466	5.4	21.0	451	735	782	790	836	Do.
226	3.113	73.0	68.0	21.0	171	411	231	457	5.1	20.8	424	749	791	816	823	Do.
227	3.113	70.0	68.5	21.0	203	438	271	478	4.8	20.7	372	722	821	816	883	Do.
229	3.111	70.0	68.5	21.0	180	424	244	468	5.0	21.2	409	809	827	831	849	Do.
230	3.113	67.1	72.5	21.0	195	443	223	485	4.0	21.4	427	769	881	841	794	Do.
231	3.115	67.1	72.5	21.0	206	443	243	472	4.9	21.4	389	731	871	835	839	Do.
232	3.109	67.1	72.5	21.0	194	458	235	460	5.0	21.6	441	768	890	829	838	Do.
233	3.112	68.0	55.4	21.0	200	498	265	505	5.2	21.5	290	648	857	846	870	Do.
335	3.114	68.0	55.4	21.0	233	470	282	484	4.6	20.7	316	645	858	839	842	Do.
336	3.113	64.4	48.2	21.0	262	472	268	487	4.5	20.5	220	675	886	857	911	Do.
237	3.115	64.4	48.2	21.0	263	454	250	357	4.5	20.5	221	648	877	846	887	Do.
271	3.115	68.0	50.0	21.0	300	500	357	532	4.7	21.1	309	742	826	823	876	Do.
272	3.118	68.0	59.0	21.0	238	381	255	465	4.8	21.4	433	729	841	855	864	Pat A, 2-inch shrinkage crack ¼ inch from edge.
274	3.111	68.0	59.0	21.0	219	432	353	451	4.8	21.2	420	739	829	839	877	Pat A, ½-inch shrinkage crack ¼ inch from edge.
275	3.116	68.0	68.0	21.0	170	416	143	403	4.8	21.4	387	786	791	790	859	Pat A, 1½-inch shrinkage crack ¼ inch from edge.
283	3.111	68.0	70.0	21.0	147	419	175	404	4.9	21.1	404	717	805	840	851	Normal.
289	3.114	68.0	70.0	21.0	138	240	239	444	5.0	21.1	421	725	760	830	874	Do.
291	3.113	68.0	75.0	21.0	153	377	184	405	4.9	21.0	431	761	774	816	856	Pat A, warped $\frac{1}{32}$ inch around edge.
292	3.114	68.0	75.2	21.0	139	369	189	405	4.9	21.1	436	777	758	814	860	Normal.
293	3.112	68.0	75.2	21.0	152	364	259	456	4.7	20.7	425	768	765	819	871	Do.
301	3.112	68.0	74.5	21.0	134	450	297	486	4.9	21.5	427	799	798	829	867	Do.
302	3.110	68.0	74.5	21.0	190	466	318	517	4.8	21.3	433	760	803	821	868	Do.
303	3.110	68.0	59.9	21.0	208	447	290	508	5.0	21.6	428	759	796	835	870	Do.
304	3.113	68.0	59.9	21.0	225	464	320	524	4.7	21.4	422	732	783	828	870	Do.
309	3.111	68.0	70.7	21.0	156	388	227	461	4.8	21.5	403	733	727	818	868	Do.
312	3.110	68.0	62.6	21.0	176	425	215	468	4.8	21.6	386	729	823	838	843	Do.

313...........	3.112	68.0	62.6	21.0	182	437	206	474	5.1	21.7	376	733	795	844	852	Do.
314...........	3.112	68.0	62.6	21.0	154	448	252	482	5.1	21.7	356	715	807	839	832	Do.
316...........	3.116	68.0	66.0	21.0	135	425	174	443	4.8	21.5	408	707	812	823	823	Do.
317...........	3.114	68.0	66.0	21.0	127	416	188	440	4.9	21.5	416	705	811	847	822	Do.
318...........	3.118	68.0	66.0	21.0	133	404	194	443	5.2	21.2	420	706	807	824	834	Do.
Average ...	3.113	69.7	66.5	21.0	184	421	244	459	4.9	21.2	398	733	811	816	851	

Table 4 contains the results of all the physical tests made of the typical Portland cement that was used in the present series of concrete beams. In the column "Register No." is given the register number of the cement used. Each number corresponds to two cans of 800 pounds each of typical Portland cement. The sample for each test was taken as already indicated.

As these tests were made with the sole idea of checking the uniformity with which the typical Portland cement was prepared, a full series of neat and sand tests was thought unnecessary and undesirable, for it would entail too much routine work on the part of the constituent-materials laboratory. Accordingly, only tension tests on neat cement were made.

SAND.

The same sand was used with all the aggregates tested. It is known as Meramec River sand, and is composed of flint grains having comparatively smooth surfaces. The yellowish-brown color of the flint imparts a tint of the same color to the sand as a whole.

Tables 5 and 6 (p. 17) give the results of the physical tests on this material. The granulometric analysis in Table 6 shows the sand to be rather finer than desirable. The percentage of voids was computed from the weight per cubic foot and the specific gravity.

Table 7 (p. 18), which contains the results of the tests made on the cement used in the preparation of the test pieces reported in Table 5, will aid in the interpretation of the values given in the latter table.

TABLE 5.—*Tests of mortar made with Meramec River sand (Sd. 43) and typical Portland cement (Ct. 140) in concrete beams.*

Fineness of sand.	Proportion of mortar.	Water (per cent).	Temperature (°F.).		Tensile strength (pounds per square inch).					Compressive strength (pounds per square inch).					Transverse strength (pounds per square inch).				
			Air.	Water.	7 days.	28 days.	90 days.	180 days.	360 days.	7 days.	28 days.	90 days.	180 days.	360 days.	7 days.	28 days.	90 days.	180 days.	360 days.
Passed ¼-inch screen.	1:3	11.5	71.0	68.0	274	438	418	443	480	2,375	4,075	5,625	5,125	5,172	594	882	1,044	972	1,080
					263	422	415	467	473	2,250	4,175	5,425	4,900	5,200	576	936	1,008	1,080	1,098
					260	416	446	487	486	2,325	4,050	5,650	4,850	5,210	594	846	1,026	972	1,062
	Average				266	425	426	466	480	2,317	4,100	5,567	4,958	5,194	588	888	1,026	1,008	1,080
	1:4	11.0	71.0	68.0	180	302	352	391	401	1,375	2,450	3,625	3,600	3,715	396	612	810	846	864
					186	294	352	355	408	1,375	2,350	3,900	3,675	3,775	396	666	864	846	900
					190	306	361	373	416	1,325	2,375	3,812	3,550	3,740	378	630	882	900	846
	Average				185	301	355	373	408	1,358	2,392	3,780	3,608	3,743	390	636	852	864	870
Size, 30-40	1:3	11.5	65.0	68.0	215	293	343	359	360	1,425	2,750	3,400	3,550	3,600	396	630	882	774	828
					224	294	350	353	372	1,400	2,700	3,450	3,500	3,618	414	648	954	810	900
					207	299	344	335	368	1,425	2,650	3,375	3,675	3,642	432	612	864	882	792
	Average				215	295	346	349	367	1,417	2,700	3,408	3,575	3,630	414	630	900	822	840

TABLE 6.—*Physical properties of sand and other materials forming aggregates used in concrete beams.*

Kind of material.	Specific gravity.	Percentage of voids (computed).	Weight (pounds per cubic foot).	Percentage passing sieve or screen—												
				200.	100.	80.	50.	40.	30.	20.	10.	¼-inch.	½-inch.	¾-inch.	1-inch.	1½-inch.
Cinders	1.530	50.7	47.0	2.84	4.17	4.91	6.45	8.26	10.48	13.66	21.07	36.89	60.32	81.44	89.68	100
Granite	2.585	40.9	95.3	1.59	2.29	2.62	3.22	3.74	4.38	5.45	8.50	19.88	57.54	99.25	99.71	100
Gravel	2.450	33.0	102.4	0	0	0	0	0	0	0	.95	43.0	79.3	95.2	98.5	100
Limestone	2.489	37.1	97.7	2.96	3.48	3.70	4.18	4.68	5.23	6.21	10.69	28.71	60.86	96.04	99.37	100
Meramec River sand	2.597	37.9	100.6	.20	1.30	3.60	13.90	37.00	64.00	81.50	97.00	100	....	....	....	....

AGGREGATE.

The results of the physical tests on the granite, gravel, cinders, and limestone used in the plain beams are reported in Table 6. The crushing strength of the 1:2:4 concrete made of these aggregates is given in connection with the results of tests on the plain beams, in Table 10 (pp. 48–53).

TABLE 7.—*Tests of cement 140, used in testing Meramec River sand (strength in pounds per square inch).*

Kind of test.	Neat.						1:3 mortar.				
	1 day.	7 days.	28 days.	90 days.	180 days.	360 days.	7 days.	28 days.	90 days.	180 days.	360 days.
Tension..........	362	710	696	775	827	846	342	527	445	405	414
	375	700	705	792	811	853	375	540	445	388	408
	372	718	709	781	813	831	364	531	413	394	405
Average.......	370	709	703	783	817	843	360	533	434	396	408
Compression.....	3,425	9,300	10,512	12,288	13,980	14,274	1,570	3,200	....	5,025	5,500
	3,275	9,325	11,125	12,612	13,725	14,410	1,555	3,300	3,698	5,025	5,425
	3,300	9,175	10,497	12,862	13,803	14,320	1,735	3,025	3,400	4,800	5,239
Average.......	3,333	9,266	10,711	12,590	13,836	13,335	1,620	3,175	3,549	4,950	5,388
Transverse......	756	1,440	1,872	1,998	1,944	2,142	......	......	......	......	......
	792	1,440	1,908	2,016	2,088	2,232	......	......	......	......	......
	774	1,476	1,944	1,962	2,034	2,124	......	......	......	......	......
Average.......	774	1,452	1,908	1,992	2,022	2,166	......	......	......	......	......

Remarks.—Fineness: Residue on No. 100 sieve, 6.8 per cent; on No. 200 sieve, 22.8 per cent. Specific gravity, 3.12. Time of set: Initial, 142 minutes; final, 428 minutes. Soundness: Pat test in air at 70° F., normal; in water at 70° F., normal; in water at 212° F., 3 hours, normal; in steam at normal pressure, 5 hours, normal. Water used in mixing: Neat, 20.5 per cent; mortar, 8.9 per cent. Temperatures: Of air, 71.0° F.; of water, 68.0° F.

PREPARATION OF TEST PIECES.

METHODS OF PROPORTIONING.

A 1:2:4 volume proportion was adopted for all the concrete used in the following tests. Since, however, the volume of a given weight of dry sand is greatly affected by the percentage of moisture present, it was thought best to do the actual proportioning by weight. The weight of 1 cubic foot of cement was assumed to be 100 pounds. The weight per cubic foot of the dry, loose sand and the dry, loose aggregate as determined by tests in the constituent-materials laboratory, was used in reducing the proportions by volume to the proportions by weight.

With this as a basis, the necessary weight of dry material for the desired batch was determined. Since the sand and stone, as stored in the bins, contained an appreciable amount of moisture, the dry weight of the material had to be increased by the weight of the moisture present before the batch could be weighed out. The percentage of moisture was determined on a 500-gram sample of the sand and stone each day on which beams were molded.

The above method of correcting for moisture was followed in the series of concrete beams and in the greater part of the first reinforced beam series. It was noticed from time to time, however, that the concrete when dumped from the mixer was not always of the same consistency, in spite of the fact that the total weight of water present (weight of water added plus the weight of the moisture in the sand and the stone) was a constant. A moisture determination was then made on a sample representing as nearly an average of the material in the bin as it was possible to obtain, and this was then maintained constant and gave much better results. The effect on the consistency of a given change in the weight of the moisture in the sand or stone does not appear to be the same as that of an identical change in the weight of the water added to the batch, the difference probably being due to the fact that the moisture test is only local and does not represent the true average of the material in the bin.

It should be noted here that the proportions by volume of the cinder concrete are nearer 1:2:5 than 1:2:4. This is due to an error in making the moisture determination at the time the weight per cubic foot was determined. The weight per cubic foot of the cinders, including apparently 11.1 per cent moisture, was reported as 68.1 pounds. Using these figures gives 61.3 pounds per cubic foot for the weight of the dry, loose cinders. These determinations were accepted as correct until a sample, which had been forgotten in the oven, showed 23 per cent moisture present. This error in the weight per cubic foot, due to insufficient drying of the test sample, was not discovered until the series of cinder beams was almost completed. While a new determination of the weight per cubic foot was made and the proportions by weight and volume modified accordingly, it was thought best to use these proportions and the correct weight per cubic foot on the remaining cinder beams rather than the 1:2:4 volume proportions, in order to make the cinder beams comparable among themselves even if not strictly comparable with the beams of other aggregates.

The weight per cubic foot, as redetermined, was found to be 47.0 pounds.

METHOD OF MIXING AND CONSISTENCY.

MIXING.

All concrete was mixed in a motor-driven cubic-yard cube mixer, which is equipped with a charging hopper. All water used in mixing concrete was weighed and was supplied to the mixer through a hose attached to a water barrel, which is mounted on a platform scale on a support above the mixer. To insure uniform conditions the interior of the mixer was wetted down each morning before the first mix of the day. All concrete was mixed two minutes dry and three minutes wet, after which it was dumped on the cement floor, shoveled into wheelbarrows and wheeled to the molding floor. Sufficient material was charged into the mixer to make two beams, two cylinders, and two cubes from the same batch of concrete.

CONSISTENCY.

Definition.—The three consistencies, wet, medium, and damp, as here used, represent each a certain characteristic behavior and appearance of the concrete in the mixer, on the floor, and in the mold when subjected to tamping. In order to eliminate the personal equation as far as possible, the amount of water required to bring the batch to a desired consistency for a particular aggregate was carefully determined by trial before the test pieces were molded. Thereafter the weight of water to be used with each aggregate for that consistency could be obtained by making a simple correction each day, depending upon the percentage of water contained in the aggregate as it came from the bins. The total amount of water, including moisture, was expressed as a percentage of the total weight of the dry material and was maintained constant.

A brief description of the consistencies is given. It should be recognized that the consistencies as defined are purely arbitrary, but each, it is thought, represents a characteristic appearance and behavior, and, with a little practice, is readily distinguished from the others.

Wet consistency.—Concrete of wet consistency has a smooth and somewhat viscous appearance in the mixer, or immediately before dumping. It flows back from the ascending side of the mixer without any tendency toward "breaking" over at the top. The upper surface of the concrete in the bottom of the mixer rolls underneath the mass smoothly and is carried upward by adhesion to the metal. When dumped, it stands on the floor in a low pile, having a smooth surface, and showing neither voids nor individual stones. It can not be compacted by tamping in the molds, but splashes under the action of the tamper. When finished, water stands from one-fourth to one-half inch deep over the surface of the mold.

Medium consistency.—Concrete of medium consistency has a smooth appearance in the mixer, but shows a tendency to lump. As compared to that of wet consistency it flows less smoothly and is carried higher by the ascending side of the mixer, part flowing back smoothly and part breaking over at the top in lumps. When dumped, it stands in a higher pile with steeper side slopes, exhibiting a somewhat lumpy appearance, and showing individual stones, but no voids. The stones show an even coating of sand mortar. No water collects on the surface of the beam in the mold. The surface is easily finished with a trowel.

Damp consistency.—Concrete of damp consistency is decidedly granular in the mixer with little tendency to lump. The material is carried to the top of the mixer and falls in individual stones and fragments of mortar. When dumped, it stands at the same angle as medium concrete, showing both individual stones and voids. The surface of the pile is irregular. In the mold it offers considerable resistance to tamping, but compacts fairly well under hand tamping. No water flushes to the surface and it can not be finished smooth by troweling.

METHOD OF MOLDING.

BEAMS.

The beam molds consisted of three long steel channels with flanges turned outward, forming the sides and bottom of the mold. The ends were closed by short pieces of channels. The side and end pieces were removable. The molds were oiled before the concrete was placed, to prevent adhesion to the surface of the steel. In molding the plain beams the concrete was deposited in three layers of about equal thickness. The tamping was done by hand with a 13¾-pound tamper having a rectangular head 1¼ by 3½ inches. The tamping was started at one side of one end of the mold and the tamper moved toward the opposite side, the width of the tamper at each stroke. The tamper was then set forward and the process repeated. In this way each part of the layer was tamped once. The mold was gone over twice in this way, after which the concrete was spaded back from the sides of the mold and the layer tamped a third time. The same operation was followed for each of the three layers. The surface of each beam was finished as smooth as possible by troweling.

The side and end pieces of the mold were removed at the end of twenty-four hours, and the beam was covered with burlap and allowed to remain on the bottom channel until moved into the moist room.

CYLINDERS AND CUBES.

In order to make the compression test representative of the true crushing strength of the concrete in the beam, the cylinders and cubes were molded from the same batch as the beam of the same number. They were molded in cast-iron separable molds, which were oiled previous to placing the concrete. The concrete was deposited in layers approximately 3 inches thick, and each layer was tamped twice, a circular hand tamper 3½ inches in diameter and weighing 7 pounds being used for the cylinders and a rectangular tamper 3½ by 1¼ inches, weighing 13¾ pounds, for the cubes.

In molding the cubes an effort was made to "spade" back the concrete from the sides of the mold, as was done in molding the beams.

The top surfaces of the cubes and cylinders were finished smooth with a trowel. All molds were removed at the end of twenty-four hours, and the test pieces were marked and transferred to the moist room.

MOVING AND STORAGE.

The large number of beams to be molded and the small space available made it imperative that the beams be moved as soon as possible. In no case could they remain where molded for more than 12 or 16 days. Since a concrete beam without reinforcement, and weighing about 1,200 pounds, has very little tensile resistance at this age, it was very important that they be handled at points that would prevent any chance of injury when being moved to the moist room. The following plan was followed, and was entirely satisfactory:

The channel forming the bottom of the mold was placed with the flanges turned down. At the points where the beams were supported in moving them, the webs of the bottom channels were cut away for a width of $1\frac{9}{16}$ inches. Prior to molding this slot was closed by a filler resting on the uncut flanges. When the beam was to be moved, this filler was driven out and a slightly narrower piece, which projected $1\frac{1}{4}$ inches beyond each side of the beam, was substituted.

A stirrup hanging from the chain blocks suspended from trolleys running on overhead **I** beams, was hooked under these projecting ends and lifted a 13-foot beam at two points 8 feet apart, which give equal positive and negative bending moment, and consequently minimum stresses in a beam of that length.

The beams in the moist room were stored six high, being supported at the same points as when brought to the damp closet.

All test pieces were sprinkled from a hose three times each day—at midnight, at 8 a. m., and at 4 p. m.—both before and after being placed in the moist room.

The temperature on the molding floor and in the moist room was recorded on a self-recording thermometer, and was maintained as near 70° as possible.

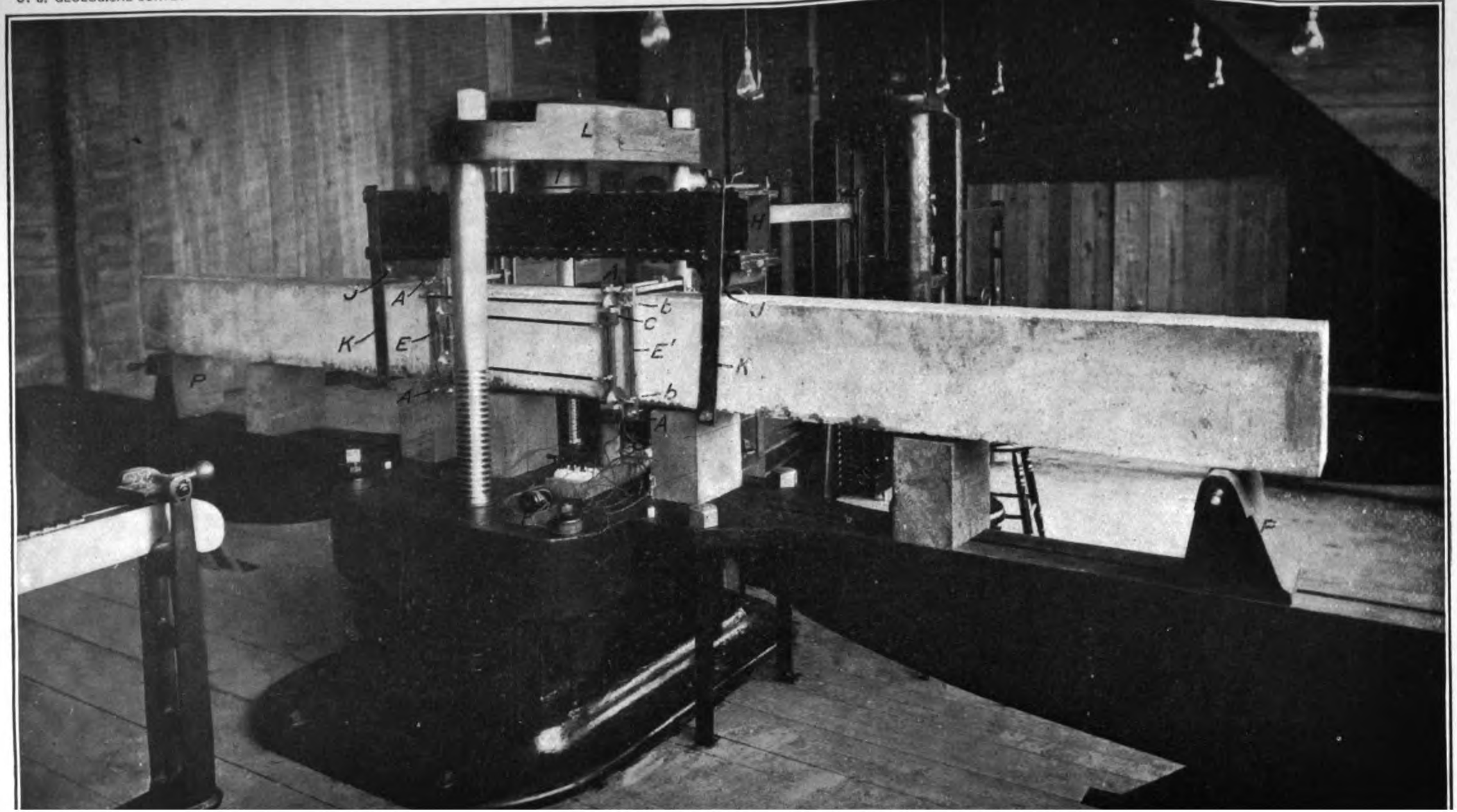
METHODS OF TESTING.

BEAMS.

LONG BEAMS.

APPARATUS.

Pl. I shows a photograph of a beam in place. The supports "P" for the beams have cylindrical top surfaces, and are so designed as to give a slight yielding motion outward, the object being to prevent any restraint of the beam which might follow from the lengthening of the lower fiber.


L
I
H
J
A
K
E
P
A
A
b
C
E'
b
A
J
K
F

The deformeter yokes (E, E′) are fastened to the beam by tightening the nuts A, which force the contact points (b) and those directly opposite on the far side of the beam, against the surface of the concrete. The yokes are equidistant from the center of the beam, the contact points being 29.25 inches apart for the outer yokes and 24 inches apart for the inner set. The contact points of the outer set were 10 inches apart vertically and those of the inner yokes 5.75 inches apart. Both yokes were centered on the horizontal axis of the beam, thus bringing the contact points of the outer yokes 0.5 inch below the top and 0.5 inch above the bottom. The inner yokes were used only on some of the earlier beams in order to test the conservation of plane section. Four pins directly in line with the contact points on E engage cylindrical holes in the ends of the four rods, the other ends of which rest lightly on hard rubber rollers fastened to the arms C, which are rigidly connected to the yoke E.

Four micrometer screws reading directly to 0.0001 inch work in bushings fastened to the yoke E′. When any micrometer screw is brought in contact with the end of the corresponding rod, an electric contact is made, which causes a click in the telephone receiver F. Both yokes are divided into two vertical halves by rubber insulation, thus making it possible to read micrometers on both sides of the beam simultaneously.

METHOD OF ZERO DEFORMATIONS.

The deformation of concrete in compression in a beam is obtained from a reading of the upper micrometers, while the lower ones give the elongation of concrete. The readings of both upper and lower micrometers, making the usual assumption of conservation of plane section, fix the position of the neutral axis. The beams were all tested on a 12-foot span by two equal loads, applied at the third points of the span.

The load apparatus consists of a box girder (H) built of two 6-inch channels with a ½-inch cover plate on the top and the bottom. The load is transmitted from the testing machine to the box girder through a spherical bearing block (I), and from the box girder to the beam by two 2-inch steel rollers (J) bearing on two steel blocks (not shown) set in plaster of Paris. The upper surface of these blocks is a cylinder of very large radius whose axis is parallel to the length of the beam. With the exception of these bearing blocks the entire load apparatus is suspended from the top head (L) of the testing machine by a bolt passing through the spherical bearing block and engaging a plate on the inner surface of the box girder. The steel rollers (J) are kept in place by the casting which extends a trifle below their axis.

On commencing a test the bearing blocks are removed and yokes (K) are passed under the test beam and over the box girder directly above the 2-inch rollers. The head (L) is then run up until the reaction at the ends of the test beam has been so reduced that the total positive bending moment area is equal to the total negative bending moment area within the gage length, considering the beam as a continuous girder over four supports, viz, the two end supports and the two intermediate yokes.

This method is used for the following reason: In tests of beams as usually made, the upper and lower fibers of the beam are already deformed and are under stress due to the weight of the beam when the first, or zero, reading of the deformeters is taken; the deformations computed from these readings are too small by an amount which becomes relatively more and more important as the breaking loads decrease and which in the case of plain beams (many of which fail by a load but little in excess of the weight of the beam) becomes a very large part of the ultimate deformation.

When a beam rests freely on supports, the upper and lower fibers are deformed on account of the bending moment due to the weight of the beam. When the supports are at the ends of the beam the upper fibers are shortened and the lower are lengthened. For equal moduli of elasticity in tension and compression, which are constant for concrete under small loads, the deformation at any point of the beam is proportional to the area of the bending-moment diagram over that length. Therefore, when the total positive bending moment area in the gage length of the deformeters equals the total negative bending moment area in the gage length, the net total deformation in that length is zero, and both the upper and lower fibers of the beam have the same length as when unstressed. For a particular reaction at the ends of the beam the positive bending moment area in the gage length is equal to the negative bending moment area. In order to get this reaction the beams are supported at the third points by the head of the machine as previously described. As the stirrups under the third points of the span take more and more of the weight of the beam the end reactions become smaller and smaller and the character of the bending-moment diagram within the gage length changes until the desired condition is reached.

The method of finding the required reactions for total zero deformations within the gage length, in terms of the weight of the beam and other known quantities, may be understood by reference to fig. 1, as follows:

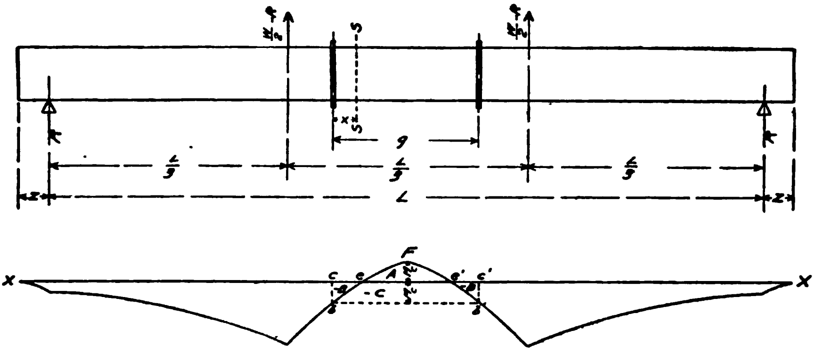


FIG. 1.—Diagrams illustrating method for computation of concrete beams. Upper diagram: Notation used. Lower diagram: Curve of bending moment within gage length (beam supported at third points).

Let L = distance between the supports.
g = gage length of deformeters.
Z = overhang of beam at each end.
$\frac{L}{3}$ = distance from each support to force exerted by each stirrup.
W = total weight of beam.
$\frac{W}{2} - R$ = force exerted by each stirrup at a distance of $\frac{L}{3}$ from the supports.
R = each reaction at end.
SS = any vertical section within the gage length at a distance, x, from one of the gage points.
M_x = bending moment at section SS.
M_0 = bending moment at deformeters, where x = 0.
M_c = bending moment at center of beam, where $x = \frac{g}{2}$.
m = constant bending moment over the gage length due to the weight of all attachments, such as bearing blocks under the load points and the deformeters. This weight is applied outside of the gage length and equally on each side of the center of the beam.

The bending moment at section SS, considering forces to the left only, is as follows:

$$M_x = R\left(\frac{L}{2}-\frac{g}{2}+x\right)+\left(\frac{W}{2}-R\right)\left(\frac{L}{6}-\frac{g}{2}+x\right)-\frac{W}{2(L+2Z)}\left(\frac{L}{2}+Z-\frac{g}{2}+x\right)^2+m.$$

Reducing to a simpler form gives:

$$M_x = \frac{RL}{3} - \frac{W}{4}\left(\frac{L}{6} + Z\right) - \frac{W}{4\left(\frac{L}{2} + Z\right)}\left(\frac{g}{2} - x\right)^2 + m.$$

The bending moment at the end of the gage length ($x = 0$) is as follows:

$$M_o = \frac{RL}{3} - \frac{W}{4}\left(\frac{L}{6} + Z\right) - \frac{Wg^2}{16\left(\frac{L}{2} + Z\right)} + m.$$

The bending moment at the center of the gage length $\left(x = \frac{g}{2}\right)$ is as follows:

$$M_c = \frac{RL}{3} - \frac{W}{4}\left(\frac{L}{6} + Z\right) + m.$$

The moment diagram between the third points, when there is both positive and negative bending moment in the gage length, is shown in fig. 1, in which xx′ is the horizontal axis of the moment diagram. The curve bee′b′ is a parabola and crosses the axis at two points (viz, e and e′) between the ends of the deformeters. Then in the gage length cc′ there is negative bending moment from c to e and from e′ to c′, and positive bending moment from e to e′. The dotted lines cb, c′b′, and bb′ are drawn for the purpose of demonstration. Then the distance M_c represents the bending moment at the center of the gage length, and M_o represents the bending moment at the end of the gage length. The negative bending-moment areas within the gage length are cbe and c′b′e′, each being represented by $-B$. The positive bending moment area within the gage length is eFe′ and is represented by A.

The condition that the positive bending moment area is equal to the negative bending moment areas is represented by the equation $A = -2B$. Adding the quantity $-C$ to both sides of the equation gives $A + (-C) = -2B - C$. The first part of this equation is the area included between the horizontal line bb′ and the parabola bFb′; that is, $A + (-C) = \frac{2}{3}g\,[M_c + (-M_o)]$.

The second part of the equation is equal to the area of the rectangle bcc′b′; that is, $-2B - C = -gM_o$.

Therefore $\frac{2}{3}g\,[M_c + (-M_o)] = -gM_o$. Whence $2M_c = -M_o$.

Substituting the values of M_o and M_c as found above gives:

$$\frac{2RL}{3}-\frac{W}{2}\left(\frac{L}{6}+Z\right)+2m=-\frac{RL}{3}+\frac{W}{4}\left(\frac{L}{6}+Z\right)+\frac{Wg^2}{16\left(\frac{L}{2}+Z\right)}-m.$$

$$\text{Whence } RL=\frac{3W}{4}\left(\frac{L}{6}+Z\right)+\frac{Wg^2}{16\left(\frac{L}{2}+Z\right)}-3m$$

$$\text{and } R=\frac{3W}{4L}\left(\frac{L}{6}+Z\right)+\frac{Wg^2}{16L\left(\frac{L}{2}+Z\right)}-\frac{3m}{L}.$$

In almost all the beams tested at the laboratories L, Z, g, and m are constant. It only remains to find W and to compute R. A table computed by the above formulà has been compiled for all the usual values of W, from which the corresponding value of R in any case can be directly read.

METHOD OF TESTING.

When the test is commenced, the top head is run up until the reactions causing equal positive and negative bending moments over the gage length are developed at the ends of the beam. The sum of these reactions will appear on the weighing beam, the testing machine having been balanced before the weight of the beam and all test apparatus comes on it. A full set of defórmeter readings is then taken.

After the readings at zero total deformations in the gage length and when the beam rests under its own weight are taken, the load is applied in increments of 200 to 1,000 pounds, depending on the stiffness of the beam, the top and bottom set of micrometer readings being recorded on the log sheets. Wood blocks are placed underneath the beam during the test, so that the distance it falls at rupture is not more than one-fourth inch.

SHORT BEAMS.

The longer portion of each beam after first failure is again tested on as great a span as its length permits, thus making a secondary series of short beams.

The load is applied by the same apparatus as that used for the long beams, but instead of being applied at the third points it is applied at points 2 feet from the center of the span. The short beams are not suspended for zero deformation readings, since for such small spans the deformation of the beam under its own weight is very small. On all short beams the outer yokes having a gage length of 29.25 inches are alone used.

CYLINDERS AND CUBES.

The cylinders and cubes are tested on a four-screw, 200,000-pound Olsen machine. To insure an even distribution of load over the entire cross section the ends of the cylinders are bedded in plaster of Paris to a thickness of about one-half inch on a piece of plate glass (previously oiled to prevent adhesion of the plaster). The bearing surfaces are made normal to the axis of the cylinder by means of a spirit level applied to its sides. The cubes are not capped with plaster of Paris, but a thin piece of asbestos is placed on a spherical bearing plate when under test, in order to take up all nonparallelism of the ends.

The load is in each case carried to failure, being applied continuously to rupture in the case of the cubes and in increments of 5,000 pounds, or approximately 100 pounds per square inch for the cylinders. For each increment gross deformations are read on two opposite sides of the cylinder over a gage length of 12 inches.

RESULTS OF TESTS.

BEAMS OF CONSTANT SPAN.

The detailed results of the tests of concrete beams 8 by 11 inches in section, 13 feet long, tested on a 12-foot span by two equal loads applied at the third points are given in Table 8 (p. 36), comprising the

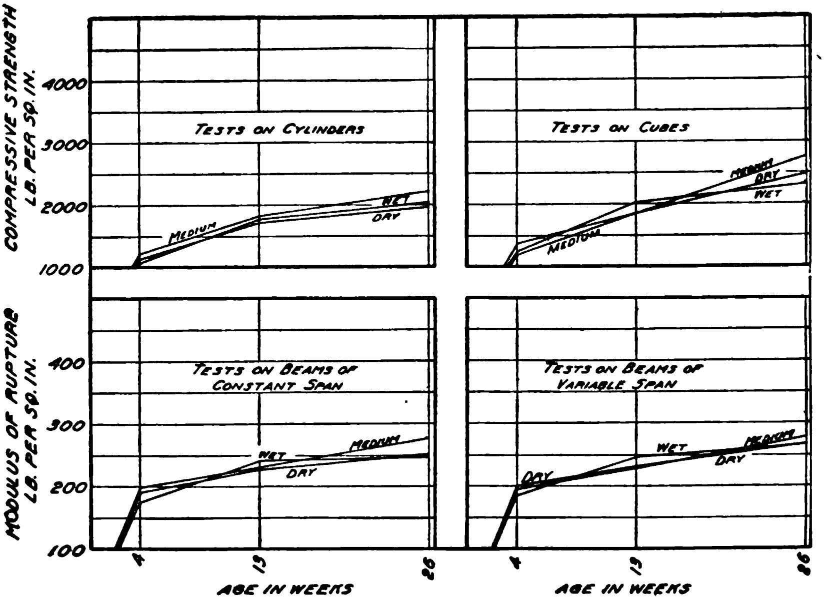


FIG. 2.—Diagrams showing the effect of age and consistency on the strength of cinder concrete.

three ages of 4, 13, and 26 weeks, and some of the results are graphically shown in figs. 2–5 and 10–13.

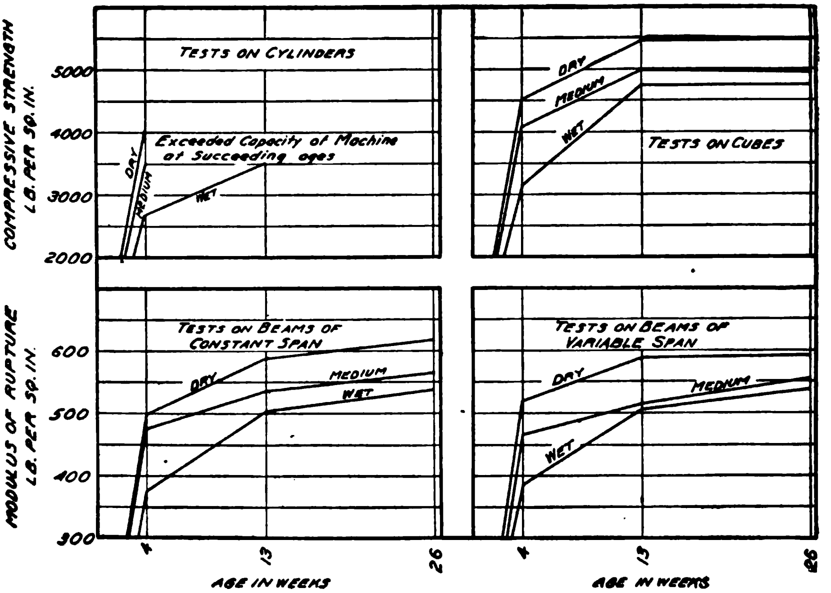


FIG. 3.—Diagrams showing the effect of age and consistency on the strength of granite concrete.

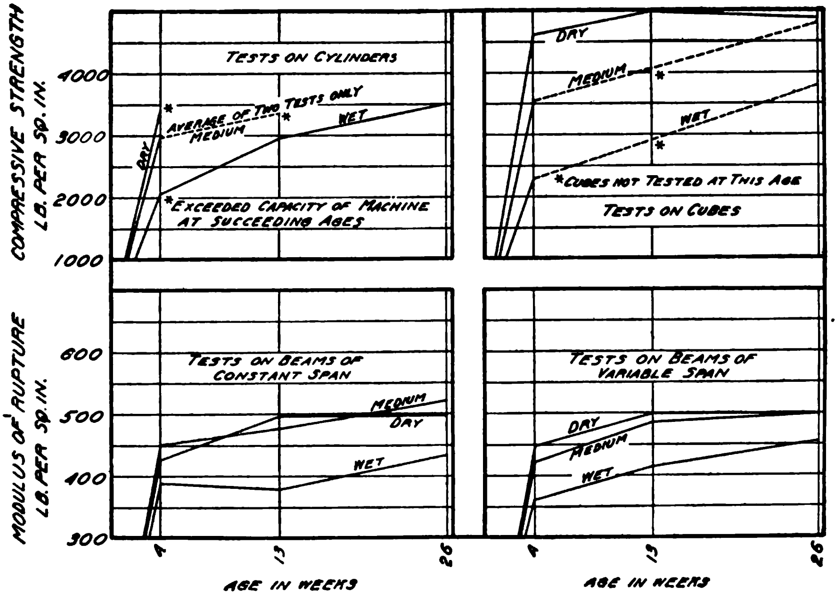


FIG. 4.—Diagrams showing the effect of age and consistency on the strength of gravel concrete.

The percentage of water is expressed in the table in terms of the total weight of the dry material. This percentage includes the weight of the moisture in the sand and aggregate, which varies from

1.5 to 2.0 per cent of the weight of the stone, from 3 to 4 per cent of the weight of the sand, and may include as much as 21 per cent of the weight of the cinders. A simple computation, using the proportions by weight, will show that this 21 per cent moisture forms as much as 43 per cent of the total amount of water, including moisture, that is necessary to bring the concrete to the desired consistency. Deduct-

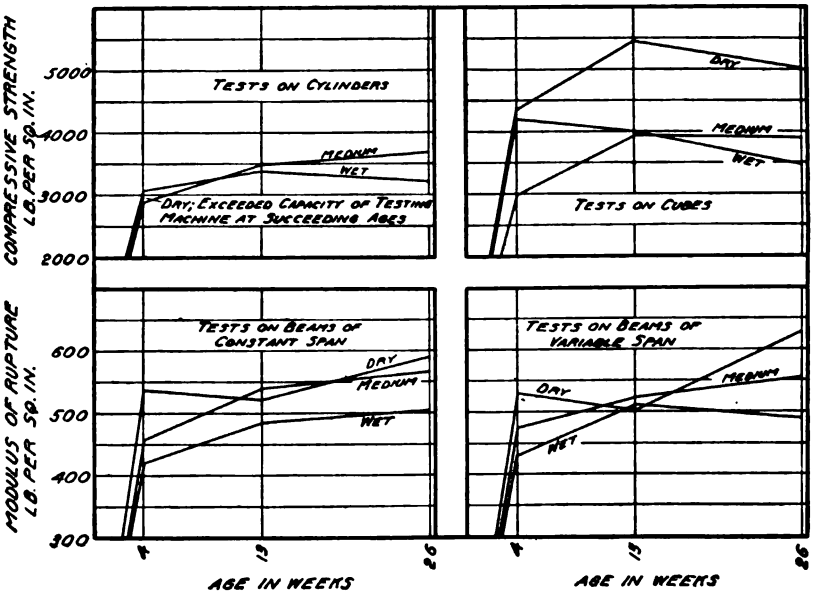


FIG. 5.—Diagrams showing the effect of age and consistency on the strength of limestone concrete.

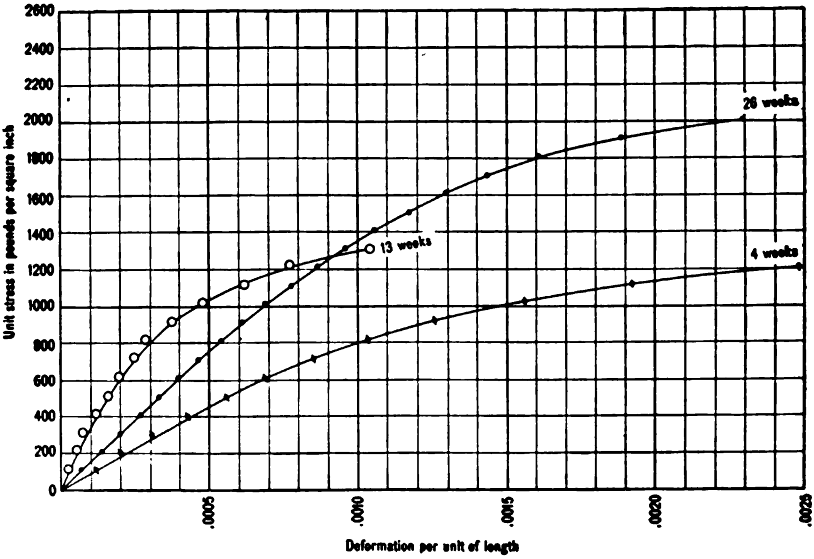


FIG. 6.—Characteristic compression-stress deformation diagrams, cinder concrete of medium consistency; ages 4, 13, and 26 weeks.

ing this 43 per cent moisture from the total percentage of water leaves about 12 per cent of the total weight of the dry material as the weight of the water added plus the weight of the moisture in the sand. This does not differ so very much from the percentage of water used for the other aggregates. As already indicated, it would seem that the influence of the water present in the stone or cinders and even for usual values of 3 to 4 per cent in the sand does not influence the consistency as greatly as does the same weight of water when added to the batch.

Column 6 of the table gives the consistency of the concrete and must be compared with the definitions of wet, medium, and damp concrete already given (p. 20).

Columns 7, 8, and 9 give the dimensions of the beam, the span being kept constant at 12 feet.

Column 10 gives the total weight of the beam, which is obtained by weighing the beam on the testing machine. The error in weighing is in no case greater than 5 pounds in either direction. Column 11 gives the weight per cubic foot of the beam.

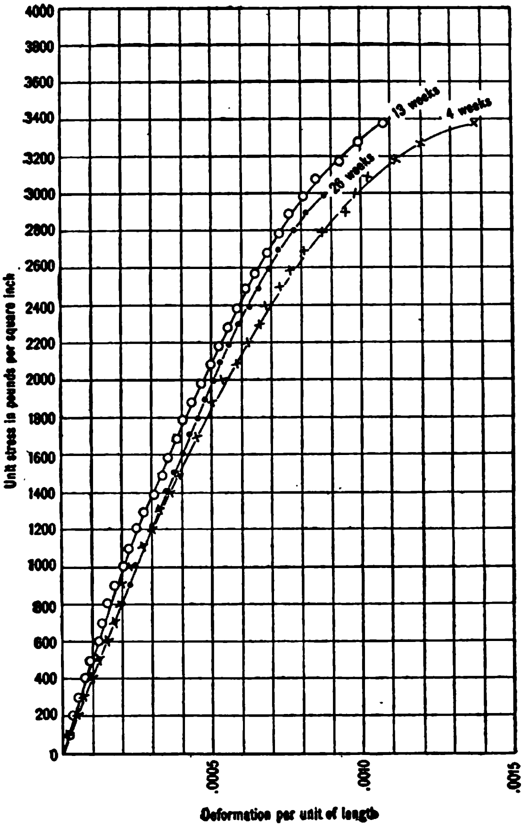


FIG. 7.—Characteristic compression-stress deformation diagrams, granite concrete of medium consistency; ages 4, 13, and 26 weeks.

Column 12 gives the unit elongation of the lower fiber when the beam rests freely on a 12-foot span subjected only to its own weight and the weight of the deformeters. This value is obtained by first taking a reading for zero total deformation as already described (p. 23) and a second reading when the beam rests as above. This value is included for the reason that in all tests made up to the present time deformations due to applied load only were read. If it is desired to compare the present tests with others already made the unit elongation as given in column 14, which was measured at a load just previous to rupture, when decreased by the value in column 12 will give the unit elongation at a point near rupture for the applied load alone.

Column 13 shows $\frac{M}{bd^2}$ (pounds per square inch) for the last load previous to failure. The relation of this value to the breaking value in column 19 is readily seen by comparison. In computing all the values of $\frac{M}{bd^2}$ given in these tables the nominal values 8 inches and 11 inches were used for the breadth (b) and the depth (d) of the beam.

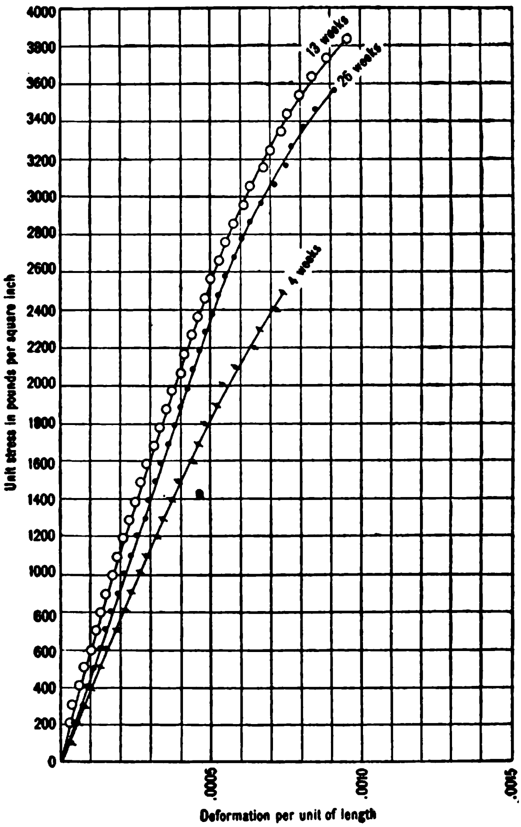


FIG. 8.—Characteristic compression-stress deformation diagrams, gravel concrete of medium consistency; ages 4, 13, and 26 weeks.

Column 14 shows the unit elongation of the lower outer fiber for the load previous to rupture. An unsuccessful attempt was made to obtain an exact value for the unit elongation of the lower fiber at rupture, but it was found impossible to take a reading of the micrometers at the exact instant of the breaking of the beam. Just previous to the break the concrete in the lower fiber elongates so rapidly that it is impossible to revolve the micrometer fast enough to maintain contact with the rod. While the lower micrometers on both sides of the beam may be read as the beam breaks the values obtained are so erratic that they have not been included in the tables of this bulletin.

The unit elongations reported under "Final deformeters" (columns 13, 14, and 15) in Table 8 are the values obtained at the last full set of readings preceding the breaking of the beam, and it must therefore be recognized that while they approximate the elongations at maximum load they are not absolute. Attention is called to the apparent relation between the values in columns 13 and 14. Separating the aggregates into cinders on one hand and the three stone concretes on the other, the elongation seems to bear a direct relation to $\frac{M}{bd^2}$ or the load carried. This comparison, however, can not be made for the cinders, owing perhaps to the nonuniformity in the strength of the clinker itself.

Column 15 shows the position of the neutral axis for the load preceding failure. This is obtained from the usual assumption of proportionality between deformation and position of the neutral axis.

The maximum load applied at the third points of the span (column 16) excludes the weight of the deformeters. The corresponding $\frac{M}{bd^2}$ is shown in column 17.

Column 18 shows the $\frac{M}{bd^2}$ for the weight of the beam, taking into consideration the effect of the 6-inch overhang on each end and also the constant weight of the deformeters.

Column 19 shows the maximum total $\frac{M}{bd^2}$, which is equal to the sum of the values in columns 17 and 18.

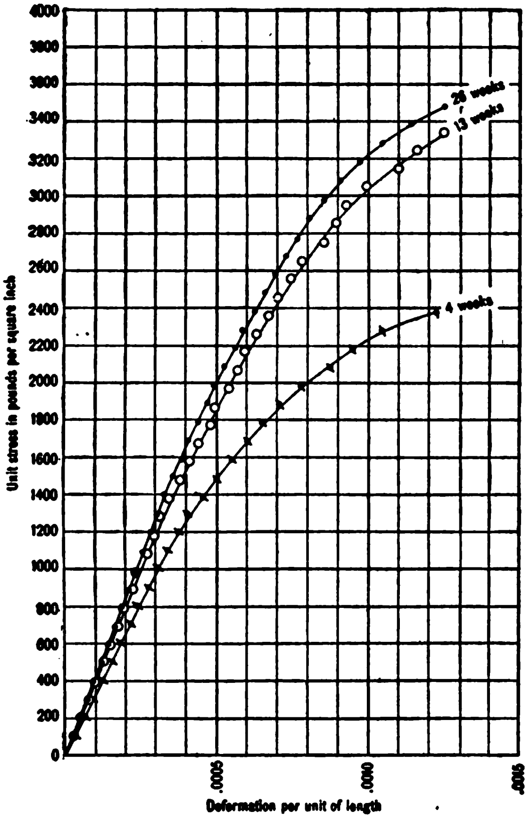


FIG. 9.—Characteristic compression-stress deformation diagrams, limestone concrete of medium consistency; ages 4, 13, and 26 weeks.

Column 20 shows the modulus of rupture in pounds per square inch. These values were obtained by multiplying those in column 19 by 6. The method of computing the modulus of rupture should be emphasized. It is based on the assumption that the coefficients of elasticity in tension and compression are equal and constant and that consequently the neutral axis remains in the center of the beam. An examination of the table shows, however, that the neutral axis actually varies from 30.4 to 63.0 per cent of the depth of the beam below the top.

Column 21 gives the distance of the break from the center of the beam, which in few cases is more than 1 foot.

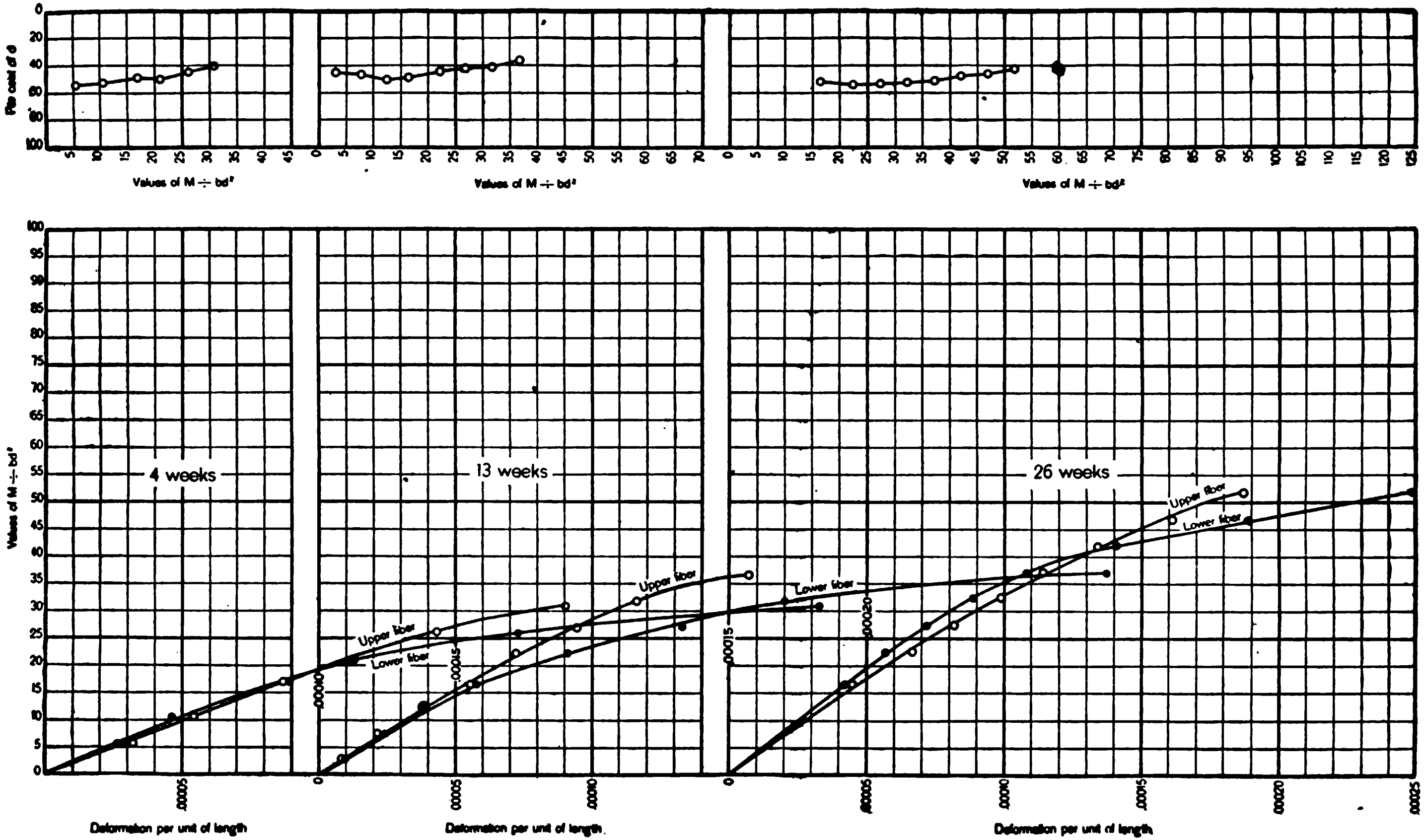


Fig. 10.—Characteristic deformation curves for flexure, cinder concrete of medium consistency; ages 4, 13, and 26 weeks.

TABLE 8.—*Tests of 13-foot concrete beams of constant 12-foot span.*

TESTED AT FOUR WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Dimensions of beam (inches).			Weight (pounds).		Unit elongation, lower outer fiber (own weight + deformeters).	Final deformeters.			Maximum applied.		Own weight + deformeters $\frac{M}{bd^2}$ (center).	Maximum total $\frac{M}{bd^2}$ (center).	Modulus of rupture $\frac{6M}{bd^2}$.	Distance of break from center (inches).
		Volume.	Weight.			Length in excess of 13 feet.	Section. Wide.	Section. Deep.	Total.	Per cubic foot.		$\frac{M}{bd^2}$ (total).	Unit elongation, lower outer fiber.	Position neutral axis.	Load.	$\frac{M}{bd^2}$ (center).				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
18	Cinder	1:2:5.06	1:2.02:2.38	21.6	Wet	0	$8\frac{1}{16}$	11	940	117.4	0.000092	25.95	0.000200	42.5	510	12.54	17.10	29.64	178	37
19	do	1:2:5.06	1:2.02:2.38	21.8	do	$\frac{3}{8}$	8	11	960	120.5	.000096	31.46	.000299	39.2	560	13.89	17.57	31.46	189	4
21	do	1:2:5.06	1:2.02:2.38	21.6	do	$\frac{3}{4}$	8	11	950	119.3	.000108	21.37	.000168	43.8	360	8.93	17.40	26.33	158	11
Average									950	119.1	.000099	26.26	.000222	41.8	477	11.79	17.36	29.14	175	
24	do	1:2:5.06	1:2.02:2.38	19.4	Med	$\frac{3}{8}$	8	11	910	114.3	.000096	35.57	.000430	35.0	760	18.85	16.72	35.57	213	2
28	do	1:2.06:5.40	1:2.07:2.54	20.4	do	$\frac{1}{2}$	8	11	900	112.9	.000100	30.43	.000263	43.9	640	15.87	16.55	32.42	195	0
29	do	1:2.06:5.40	1:2.07:2.54	20.4	do	$\frac{1}{4}$	8	11	920	115.6	.000089	30.77	.000283	40.3	560	13.88	16.89	30.77	185	3
Average									910	114.3	.000095	32.26	.000335	39.7	653	16.20	16.72	32.92	198	
37	do	1:2:5.19	1:2.01:2.44	19.0	Damp	$\frac{1}{2}$	$8\frac{1}{4}$	11	920	111.9	.000110	29.84	.000329	38.0	620	14.90	16.38	31.28	188	2
38	do	1:2:5.19	1:2.01:2.44	19.0	do	$\frac{1}{4}$	8	$11\frac{1}{4}$	940	115.5	.000125	29.75	.000374	36.2	660	15.65	16.47	32.12	193	18
39	do	1:2:5.19	1:2.01:2.44	19.0	do	$\frac{5}{8}$	8	$11\frac{1}{8}$	940	115.1	.000097	35.27	.000377	37.3	780	18.42	16.85	35.27	212	6
Average									933	114.2	.000111	31.62	.000360	37.2	687	16.32	16.57	32.89	198	
53	Granite	1:2:4	1:2.01:3.82	9.2	Wet	$\frac{1}{2}$	$8\frac{1}{16}$	$11\frac{1}{8}$	1,220	150.2	.000024	58.38	.000067	63.5	1,840	44.26	21.34	65.60	394	13
54	do	1:2:4	1:2.01:3.82	9.0	do	$\frac{3}{8}$	$7\frac{15}{16}$	$11\frac{1}{4}$	1,170	144.8	.000034	58.37	.000094	43.8	1,710	40.86	20.38	61.24	367	6
55	do	1:2:4	1:2.01:3.82	9.0	do	$\frac{5}{8}$	8	11	1,170	146.7	.000022	60.58	.000079	52.6	1,590	39.43	21.15	60.58	363	0
Average									1,187	147.2	.000027	59.11	.000080	53.3	1,713	41.52	20.96	62.47	375	
51	do	1:2:4	1:2.01:3.80	7.3	Med	$\frac{5}{8}$	8	$11\frac{1}{8}$	1,190	147.5	.000028	76.04	.000120	49.3	2,470	59.88	21.01	80.89	485	18
64	do	1:2:4	1:2.01:3.82	8.4	do	$\frac{1}{2}$	$8\frac{1}{16}$	$11\frac{1}{16}$	1,190	147.3	.000031	78.73	.000128	46.0	2,370	57.64	21.09	78.73	472	8
65	do	1:2:4	1:2.01:3.82	8.4	do	$\frac{1}{2}$	8	$11\frac{1}{8}$	1,240	153.8	.000028	68.39	.000097	49.1	2,320	56.23	21.85	78.08	468	19
Average									1,207	149.5	.000029	74.39	.000115	48.1	2,387	57.92	21.32	79.23	475	
72	do	1:2:4	1:2.01:3.82	6.9	Damp	$\frac{1}{2}$	$7\frac{15}{16}$	$10\frac{7}{8}$	1,160	148.3	.000018	72.20	.000103	60.4	2,400	60.88	21.47	82.35	494	8
73	do	1:2:4	1:2.01:3.82	6.9	do	$\frac{3}{8}$	8	$11\frac{1}{4}$	1,220	149.8	.000029	67.02	.000120	43.5	2,340	55.46	21.04	76.50	459	2
78	do	1:2:4	1:2.01:3.82	6.9	do	$\frac{1}{4}$	8	$11\frac{3}{16}$	1,220	150.8	.000024	86.94	.000135	50.6	2,890	69.27	21.27	90.54	543	8
Average									1,200	149.6	.000024	75.39	.000119	51.5	2,543	61.87	21.26	83.13	499	

88	Gravel	1:2:4	1:2.01:4.10	9.5	Wet	[illegible]	8	11	1,110	139.5	.000025	66.00	.000096	52.9	1,850	45.87	20.13	66.00	398	12
89[a]	do	1:2:4	1:2.01:4.10	9.5	do															
90	do	1:2:4	1:2.01:4.10	9.7	do		8 1/16	11 1/16	1,150	142.6	.000028	59.58	.000088	46.4	1,810	44.02	20.42	64.44	387	8
Average									1,130	141.1	.000027	62.79	.000092	49.7	1,830	44.95	20.27	65.22	391	
100	do	1:2:4	1:2.01:4.10	8.6	Med.	[illegible]	7 15/16	11 1/8	1,140	142.4	.000025	69.69	.000090	50.5	2,420	59.12	20.34	79.46	477	16
101	do	1:2:4	1:2.01:4.10	8.6	do		8 1/16	11 1/4	1,130	137.8	.000026	67.16	.000095	47.2	2,380	55.97	19.42	75.39	452	1
102	do	1:2:4	1:2.01:4.10	9.0	do		8 1/16	10 15/16	1,160	145.5	.000023	70.83	.000100	50.0	2,000	49.77	21.06	70.83	425	15
Average									1,143	141.2	.000025	69.23	.000095	49.2	2,267	54.95	20.27	75.23	451	
112	do	1:2:4	1:2.01:4.10	7.6	Damp.	[illegible]	8	11	1,110	139.3	.000023	61.04	.000088	49.0	2,050	50.83	20.13	70.96	426	7
113	do	1:2:4	1:2.01:4.10	7.6	do		8	11 1/8	1,150	142.9	.000021	59.37	.000082	47.3	2,010	48.72	20.35	69.07	414	6
115	do	1:2:4	1:2.01:4.10	7.6	do		8 1/16	10 13/16	1,110	140.6	.000035	62.68	.000109	41.8	2,050	52.20	20.67	72.87	437	0
Average									1,123	140.9	.000026	61.03	.000093	46.0	2,037	50.58	20.38	70.97	426	
128	Limestone.	1:2:4	1:2.01:3.91	10.8	Wet	[illegible]	8 1/16	11 1/16	1,170	145.0	.000032	69.16	.000119	47.7	2,390	58.13	20.75	78.88	473	8
129	do	1:2:4	1:2.01:3.91	10.8	do		8 1/16	11 3/16	1,150	139.1	.000023	66.29	.000101	53.2	2,010	46.76	19.53	66.29	398	5
130	do	1:2:4	1:2.01:3.91	11.0	do		8	11 1/8	1,170	142.0	.000026	56.64	.000084	50.9	1,990	46.14	19.78	65.92	396	5
Average									1,163	142.0	.000027	64.03	.000101	50.6	2,130	50.34	20.02	70.36	422	
141	do	1:2:4	1:2.01:3.91	10.0	Med.	[illegible]	8 1/16	11 3/16	1,170	143.2	.000028	77.13	.000127	51.4	2,390	56.84	20.29	77.13	463	6
142	do	1:2:4	1:2.01:3.91	10.0	do		8	11 1/16	1,170	146.1	.000028	69.70	.000114	49.1	2,030	49.77	20.91	70.68	424	15
143	do	1:2:4	1:2.01:3.91	10.0	do		7 15/16	11	1,170	147.8	.000032	71.05	.000110	51.4	2,390	59.72	21.32	81.04	486	3
Average									1,170	145.7	.000029	72.63	.000117	50.6	2,270	55.44	20.84	76.28	458	
150	do	1:2:4	1:2.01:3.91	8.4	Damp.	[illegible]	8	11 3/16	1,170	144.2	.000026	87.32	.000125	52.6	3,190	76.45	20.45	96.90	581	5
151	do	1:2:4	1:2.01:3.91	8.4	do		8	11	1,140	143.2	.000027	80.64	.000136	45.5	2,800	69.42	20.64	90.06	540	5
152	do	1:2:4	1:2.01:3.91	8.4	do		8	11 1/16	1,150	143.5	.000038	79.66	.000142	48.0	2,500	61.28	20.58	81.86	491	15
Average									1,153	143.6	.000030	82.54	.000134	48.7	2,830	69.05	20.56	89.61	587	

[a] Accidentally broken before test.

TABLE 8.—*Tests of 13-foot concrete beams of constant 12-foot span*—Continued.

TESTED AT THIRTEEN WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Dimensions of beam (inches).			Weight (pounds).		Unit elongation, lower outer fiber (own weight + deformeters).	Final deformeters.			Maximum applied.		Own weight + deformeters $\frac{M}{bd^2}$ (center).	Maximum total $\frac{M}{bd^2}$ (center).	Modulus of rupture $\frac{6M}{bd^2}$.	Distance of break from center (inches)
		Volume.	Weight.			Length in excess of 13 feet.	Section. Wide.	Section. Deep.	Total.	Per cubic foot.		$\frac{M}{bd^2}$ (total).	Unit elongation, lower outer fiber.	Position neutral axis.	Load.	$\frac{M}{bd^2}$ (center).				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
2..........	Cinders...	1:2:4.86	1:2.02:2.29	22.15	Wet...	3/8	8	11 3/16	960	118.4	0.000042	36.16	0.000142	47.8	890	21.33	16.99	38.32	230	15
8..........	.....do....	1:2:4.79	1:2.02:2.25	22.3	...do..	1/2	8	11 1/8	940	116.6	.000053	36.72	.000200	41.8	1,010	24.48	16.85	41.33	248	14
9..........	.....do....	1:2:4.79	1:2.02:2.25	22.0	...do..	3/8	8	11 1/8	930	115.3	.000066	36.80	.000275	37.4	980	23.76	16.68	40.44	243	21
Average	....	....	....	....	....	....	....	....	943	116.8	.000054	36.56	.000206	42.3	960	23.19	16.84	40.03	240	......
3..........	Cinders...	1:2:5.13	1:2.02:2.41	21.4	Med...	3/8	8	11 1/8	920	114.2	.000051	41.72	.000284	37.6	1,180	28.61	16.51	45.12	271	10
33..........	.....do....	1:2:5.21	1:2.01:2.45	21.0	...do..	1/2	8	11 1/16	920	114.8	.000073	32.39	.000293	36.9	700	17.16	16.70	33.86	203	9
34..........	.....do....	1:2:5.21	1:2.01:2.45	20.0	...do..	3/8	8 1/16	11 1/8	930	114.4	.000058	36.51	.000287	35.4	830	19.96	16.55	36.51	219	2
Average	....	....	....	....	....	....	....	....	923	114.5	.000061	36.87	.000288	36.6	903	21.91	16.59	38.50	231	......
40..........	Cinders...	1:2:5.19	1:2.01:2.44	19.0	Damp.	5/8	8 1/16	11 1/4	940	114.3	.000062	35.63	.000238	38.8	890	20.93	16.35	37.28	224	19
41..........	.....do....	1:2:5.19	1:2.01:2.44	19.0	...do..	1/4	8	11 1/8	940	116.8	.000073	36.72	.000320	36.0	930	22.54	16.85	39.39	236	15
42..........	.....do....	1:2:5.19	1:2.01:2.44	18.9	...do..	5/8	8	11 1/16	930	115.9	.000091	32.32	.000292	33.2	780	19.12	16.87	35.99	216	3
Average	....	....	....	....	....	....	....	....	937	115.7	.000075	34.89	.000283	36.0	867	20.86	16.69	37.55	225	......
56..........	Granite...	1:2:4	1:2.01:3.82	8.7	Wet ..	1/4	8	11 1/8	1,200	149.1	.000023	68.69	.000078	52.6	2,310	55.99	21.18	77.17	463	16
57..........	.....do....	1:2:4	1:2.01:3.82	8.7	...do..	1/2	8	11 1/16	1,200	149.7	.000026	89.08	.000129	48.3	2,760	67.66	21.42	89.08	534	3
58..........	.....do....	1:2:4	1:2.01:3.82	9.0	...do..	3/8	8 1/16	11 1/16	1,200	148.7	.000028	78.66	.000131	44.1	2,600	63.25	21.25	84.50	507	6
Average	....	....	....	....	....	....	....	....	1,200	149.2	.000026	78.81	.000113	48.3	2,557	62.30	21.28	83.58	501	......
68..........	Granite...	1:2:4	1:2.01:3.82	8.2	Med ..	3/8	8 1/16	11 3/8	1,240	149.2	.000023	74.10	.000096	50.0	2,710	62.34	20.73	83.07	498	18
69..........	.....do....	1:2:4	1:2.01:3.82	8.2	..do..	3/8	8 1/16	11 3/16	1,240	151.9	.000026	86.12	.000119	45.7	3,120	74.20	21.44	95.64	574	5
70..........	.....do....	1:2:3.97	1:2.01:3.78	8.6	..do..	3/8	8	11 1/8	1,220	145.0	.000021	80.50	.000111	48.8	3,140	69.68	19.70	89.38	536	4
Average	....	....	....	....	....	....	....	....	1,233	148.7	.000023	80.24	.000109	48.2	2,990	68.74	20.62	89.36	536	......
79..........	Granite...	1:2:4	1:2.01:3.82	6.9	Damp.	3/8	8 1/16	11	1,160	144.5	.000032	89.70	.000160	44.0	3,050	75.03	20.82	95.85	575	16
80..........	.....do....	1:2:4	1:2.01:3.82	7.0	..do..	1/2	8 1/16	11 3/16	1,200	146.9	.000024	95.94	.000162	43.7	3,400	80.87	20.78	101.65	610	9
81..........	.....do....	1:2:4	1:2.01:3.82	7.0	..do..	1/2	8	11 1/8	1,160	143.9	.000024	98.08	.000155	47.1	3,200	77.57	20.51	98.08	588	0
Average	....	....	....	....	....	....	....	....	1,173	145.1	.000027	94.57	.000159	44.9	3,217	77.82	20.70	98.53	591	......

91	Gravel	1:2:4	1:2.01:4.10	9.7	Wet	½	7 15/16	11⅛	1,160	141.9	.000017	57.17	.000062	52.6	2,000	46.73	19.78	66.51	399	6
92	do	1:2:4	1:2.01:4.10	9.9	do	[illegible]	8	11	1,160	145.2	.000023	50.74	.000057	54.1	1,410	34.96	20.98	55.94	336	24
93	do	1:2:4	1:2.01:4.10	9.9	do	[illegible]	8	11¼	1,170	143.7	.000026	57.91	.000081	46.6	1,990	47.17	20.22	67.39	404	11
Average									1,163	143.6	.000022	55.27	.000067	51.1	1,800	42.95	20.33	63.28	380	
103	Gravel	1:2:4	1:2.01:4.10	9.0	Med	½	8 1/16	10 15/16	1,170	146.5	.000021	70.62	.000082	55.5	2,330	57.73	20.86	78.59	472	14
104	do	1:2:4	1:2.01:4.10	9.0	do	[illegible]	8	11 1/16	1,150	143.6	.000024	79.55	.000112	45.9	2,430	59.34	20.21	79.55	477	8
105	do	1:2:4	1:2.01:4.10	9.0	do	½	7 15/16	11 1/16	1,140	143.3	.000021	80.24	.000106	51.9	2,440	60.14	20.10	80.24	481	2
Average									1,153	144.5	.000022	76.80	.000100	51.1	2,400	59.07	20.39	79.46	477	
116	Gravel	1:2:4	1:2.01:4.10	7.6	Damp.	½	8 1/16	10 15/16	1,140	142.7	.000026	80.81	.000132	45.5	2,490	61.71	20.35	82.06	492	4
117	do	1:2:4	1:2.01:4.10	8.0	do	[illegible]	8	10 15/16	1,150	145.0	.000025	81.37	.000122	48.2	2,430	60.69	20.68	81.37	488	3
118	do	1:2:4	1:2.01:4.10	8.1	do	½	7 15/16	10 13/16	1,120	144.1	.000029	73.80	.000105	46.0	2,460	63.10	21.05	84.15	515	24
Average									1,137	143.9	.000027	78.66	.000120	46.6	2,460	61.83	20.69	82.53	495	
131	Limestone	1:2:4	1:2.01:3.91	11.0	Wet	½	8	11⅛	1,190	147.6	.000028	68.65	.000096	49.5	2,260	54.79	20.41	75.20	451	5
132	do	1:2:4	1:2.01:3.91	11.0	do	[illegible]	7 15/16	11	1,170	147.7	.000026	80.93	.000116	49.3	2,760	68.97	20.70	89.67	538	10
133	do	1:2:4	1:2.01:3.91	11.0	do	¼	8	11⅛	1,180	146.6	.000024	68.72	.000094	48.6	2,400	58.18	20.24	78.42	471	19
Average									1,180	147.3	.000026	72.77	.000102	49.1	2,473	60.65	20.45	81.10	487	
126	Limestone	1:2:4	1:2.01:3.91	10.4	Med	½	8	11 1/16	1,150	143.5	.000025	89.35	.000142	44.6	2,830	69.38	19.97	89.35	536	0
127	do	1:2:4	1:2.01:3.91	10.4	do	[illegible]	8	11 5/16	1,200	146.4	.000026	94.44	.000124	50.4	3,180	74.54	19.90	94.44	567	3
140	do	1:2:4	1:2.01:3.91	10.0	do	[illegible]	7 15/16	11⅛	1,170	146.1	.000018	79.11	.000096	56.6	2,710	66.70	20.24	86.44	519	10
Average									1,173	145.3	.000023	87.63	.000121	50.5	2,907	70.04	20.04	90.08	541	
153	Limestone	1:2:4	1:2.01:3.91	8.4	Damp.	[illegible]	8	10⅞	1,150	144.0	.000026	82.30	.000155	44.5	2,620	66.47	20.66	87.13	523	12
154	do	1:2:4	1:2.01:3.91	8.4	do	[illegible]	7 15/16	10 15/16	1,150	146.1	.000032	82.00	.000136	46.3	2,430	61.41	20.59	82.00	492	22
155	do	1:2:4	1:2.01:3.91	8.4	do	[illegible]	8	10 13/16	1,160	146.3	.000034	91.32	.000138	48.5	2,820	70.72	20.60	91.32	548	15
Average									1,153	145.5	.000031	85.21	.000143	46.4	2,623	66.20	20.62	86.82	521	

TABLE 8.—*Tests of 13-foot concrete beams of constant 12-foot span*—Continued.

TESTED AT TWENTY-SIX WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Dimensions of beam (inches).			Weight (pounds).		Unit elongation, lower outer fiber (own weight + deformeters).	Final deformeters.			Maximum applied.		Own weight + deformeters $\frac{M}{bd^2}$ (center).	Maximum total $\frac{M}{bd^2}$ (center).	Modulus of rupture $\frac{6M}{bd^2}$	Distance of break from center (inches).
		Volume.	Weight.			Length in excess of 13 feet.	Section. Wide.	Section. Deep.	Total.	Per cubic foot.		$\frac{M}{bd^2}$ (total).	Unit elongation, lower outer fiber.	Position neutral axis.	Load.	$\frac{M}{bd^2}$ (center).				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
12	Cinder	1:2:4.79	1:2.02:2.25	22.4	Wet	5/8	8	11 1/16	930	115.9	0.000045	40.78	0.000216	44.0	1,020	25.01	16.26	41.27	248	5
15	do	1:2:4.79	1:2.02:2.25	22.4	do	1/2	8	10 7/8	900	114.2	.000045	36.60	.000146	47.9	950	24.09	16.31	40.40	242	11
16	do	1:2:5.06	1:2.02:2.38	21.3	do	3/8	8 1/16	11 1/16	910	112.8	.000047	40.13	.000186	42.6	1,050	25.54	15.80	41.34	248	2
Average									913	114.3	.000046	39.17	.000183	44.8	1,007	24.88	16.12	41.00	246	
5	Cinder	1:2:4.79	1:2.02:2.25	21.7	Med.	5/8	8	11 1/16	940	117.2	.000042	51.73	.000249	42.9	1,440	35.30	16.43	51.73	310	6
6	do	1:2:4.79	1:2.02:2.25	21.7	do	1/2	8	11 1/16	930	116.0	.000041	42.00	.000180	43.5	1,210	29.67	16.26	45.93	276	10
35	do	1:2:5.21	1:2.01:2.45	20.0	do	3/8	8	11 1/16	930	116.1	.000051	40.78	.000371	34.0	1,000	24.52	16.26	40.78	245	4
Average									933	116.4	.000045	44.84	.000267	40.1	1,217	29.83	16.32	46.15	277	
43	Cinder	1:2:5.19	1:2.01:2.44	19.0	Damp.	5/8	8 1/16	11 3/16	910	111.3	.000049	39.23	.000265	40.8	1,150	27.35	15.45	42.80	257	6
44	do	1:2:5.19	1:2.01:2.44	19.0	do	5/8	8	11 1/8	920	114.0	.000047	40.15	.000299	38.2	1,040	25.21	15.91	41.12	247	6
45	do	1:2:5.19	1:2.01:2.44	18.5	do	3/4	8 1/16	11 1/8	910	111.8	.000049	39.67	.000266	38.5	1,050	25.26	15.62	40.88	245	4
Average									913	112.4	.000048	39.68	.000277	39.2	1,080	25.94	15.66	41.60	250	
59	Granite	1:2:4	1:2.01:3.82	9.0	Wet	5/8	8 1/16	11 1/2	1,220	145.2	.000021	86.94	.000132	45.8	3,000	67.52	19.42	86.94	522	22
60	do	1:2:4	1:2.01:3.82	8.8	do	5/8	8	11 3/16	1,230	151.9	.000022	92.76	.000137	47.1	3,000	71.92	20.84	92.76	557	3
61	do	1:2:4	1:2.01:3.82	9.0	do	3/4	8 1/16	11 3/16	1,230	150.3	.000019	a 44.47	a .000060	a 48.5	a 1,300	a 30.92	20.68	a 51.60	a 310	1
Average									1,227	149.1	.000021	89.85	.000134	46.4	3,000	69.72	20.31	89.85	539	
71	Granite	1:2:3.97	1:2.01:3.78	8.6	Med.	3/4	8 1/16	11 7/16	1,250	149.4	.000021	88.39	.000114	48.1	3,170	72.16	20.11	92.27	554	8
74	do	1:2:4	1:2.01:3.82	8.4	do	1/2	8	11 3/16	1,220	150.5	.000024	92.60	.000141	44.3	3,280	78.62	20.68	99.30	596	15
75	do	1:2:4	1:2.01:3.82	8.4	do	3/4	8	11 1/4	1,200	147.0	.000021	91.24	.000142	46.5	3,000	71.11	20.13	91.24	547	2
Average									1,223	149.0	.000022	90.74	.000132	46.3	3,150	73.96	20.31	94.27	566	
82	Granite	1:2:4	1:2.01:3.82	7.0	Damp.	5/8	8	11 1/8	1,190	147.5	.000019	105.25	.000161	46.9	3,500	84.84	20.41	105.25	631	19
83	do	1:2:4	1:2.01:3.82	7.0	do	5/8	8 1/8	11 1/16	1,190	146.1	.000023	92.74	.000147	44.2	3,350	80.87	20.33	101.20	607	15
84	do	1:2:4	1:2.01:3.82	7.1	do	1/2	8 1/8	11 1/8	1,230	146.9	.000021	99.76	.000166	44.3	3,630	82.86	19.85	102.71	616	4
Average									1,203	146.8	.000021	99.25	.000158	45.1	3,493	82.86	20.20	103.05	618	

94	Gravel	1:2:4	1:2.01:4.10	9.9	Wet	[illegible]	8 1/8	11 7/16	1,150	136.4	.000021	63.55	.000076	53.2	2,500	56.45	18.39	74.84	449	14
95	do	1:2:4	1:2.01:4.10	9.9	do	[illegible]	8	11 5/16	1,140	139.0	.000024	65.82	.000090	48.0	2,000	46.89	18.93	65.82	395	14
96	do	1:2:4	1:2.01:4.10	9.9	do	[illegible]	8 1/8	11 5/16	1,170	140.5	.000021	76.82	.000099	49.1	2,500	57.70	19.12	76.82	461	14
Average									1,153	138.6	.000022	68.73	.000088	50.1	2,333	53.68	18.81	72.49	435	
106	Gravel	1:2:4	1:2.01:4.10	9.1	Med.	[illegible]	8	11 1/16	1,140	142.1	.000026	81.10	.000107	47.5	2,900	71.10	19.80	90.90	545	4
107	do	1:2:4	1:2.01:4.10	9.1	do	[illegible]	8 1/8	11 7/16	1,150	138.0	.000023	76.50	.000097	47.7	2,900	66.94	18.80	85.74	514	1
108	do	1:2:4	1:2.01:4.10	9.0	do	[illegible]	8 1/16	11 1/8	1,160	142.7	.000019	79.88	.000109	47.5	2,650	63.73	19.76	83.49	501	14
Average									1,150	140.9	.000023	79.16	.000104	47.6	2,817	67.26	19.45	86.71	520	
119	Gravel	1:2:4	1:2.01:4.10	8.1	Damp.	[illegible]	8 1/8	10 15/16	1,140	141.5	.000021	81.68	.000102	50.0	2,750	67.91	19.94	87.85	527	5
120	do	1:2:4	1:2.01:4.10	8.1	do	[illegible]	8 1/8	11	1,140	140.7	.000023	68.54	.000103	47.8	2,370	57.86	19.72	77.58	465	3
121	do	1:2:4	1:2.01:4.10	8.1	do	[illegible]	8 1/16	11	1,140	141.8	.000021	a 44.47	a .000062	a 45.5	a 1,450	a 35.67	19.87	a 55.54	a 333	9
Average									1,140	141.3	.000022	75.11	.000102	48.9	2,560	62.89	19.84	82.72	496	
134	Limestone	1:2:4	1:2.01:3.91	11.0	Wet	[illegible]	8 1/16	11 1/4	1,190	146.4	.000021	80.38	.000111	49.2	2,900	69.75	20.25	90.00	540	1
135	do	1:2:4	1:2.01:3.91	11.0	do	[illegible]	8 1/16	11 1/4	1,190	144.5	.000025	a 55.09	a .000081	a 48.9	a 1,500	a 35.28	19.81	a 55.09	a 331	30
136	do	1:2:4	1:2.01:3.91	11.0	do	[illegible]	8	11 1/4	1,190	145.8	.000024	79.22	.000125	44.7	2,500	59.26	19.96	79.22	475	14
Average									1,190	145.6	.000023	79.80	.000118	46.9	2,700	64.51	20.01	84.61	507	
144	Limestone	1:2:4	1:2.01:3.91	10.0	Med.	[illegible]	8 1/8	11 1/4	1,180	144.0	.000021	91.54	.000119	53.0	3,000	71.60	19.94	91.54	549	9
145	do	1:2:4	1:2.01:3.91	10.0	do	[illegible]	8	11 3/16	1,190	146.7	.000026	92.09	.000131	49.4	3,000	71.91	20.18	92.09	553	18
258	do	1:2:4	1:2.01:3.91	10.0	do	[illegible]	8	11 5/16	1,190	145.1	.000021	90.07	.000109	50.0	3,400	79.69	19.74	99.43	597	23
Average									1,187	145.3	.000023	91.23	.000120	50.8	3,133	74.40	19.95	94.35	566	
158	Limestone	1:2:4	1:2.01:3.91	8.6	Damp.	[illegible]	8	11 5/16	1,210	149.2	.000026	92.42	.000144	46.2	3,200	76.71	20.51	97.22	583	2
259	do	1:2:4	1:2.01:3.91	8.6	do	[illegible]	8 1/16	11	1,200	149.4	.000023	a 45.48	a .000049	a 50.8	a 1,000	a 24.59	20.89	a 45.48	a 273	21
260	do	1:2:4	1:2.01:3.91	8.6	do	[illegible]	8 1/16	11 1/4	1,210	147.3	.000019	90.70	.000111	48.8	3,360	79.04	20.13	99.17	595	1
Average									1,207	148.6	.000023	91.56	.000127	47.5	3,280	77.88	20.51	98.20	589	

a Not included in average.

TABLE 9.—*Tests of concrete beams of variable span.*

TESTED AT FOUR WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Dimensions of beam.				Span (ft.).	Weight (pounds).		Final deformeters.			Maximum applied.		Own weight + deformeters $\frac{M}{bd^2}$ (center).	Maximum total $\frac{M}{bd^2}$ (center).	Modulus of rupture $\frac{6M}{bd^2}$.	Distance of break from center (inches).
		Volume.	Weight.			Length.		Section (inches).			Total.	Per cubic foot.	$\frac{M}{bd^2}$ (total).	Unit elongation, lower outer fiber.	Position neutral axis.	Load.	$\frac{M}{bd^2}$ (center).				
						Ft.	In.	Wide.	Deep.												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
18..........	Cinder....	1:2:5.06	1:2.02:2.38	21.6	Wet..	9	7	8$\frac{1}{16}$	11	9	693	117.4	21.53	0.000235	32.6	1,400	21.53	9.37	30.90	185	.....
19..........	.....do....	1:2:5.06	1:2.02:2.38	21.8	...do..	6	10	8	11	6	508	120.5	27.27	.000256	40.5	4,670	28.95	4.25	33.20	199	17
21..........	.....do....	1:2:5.06	1:2.02:2.38	21.6	...do..	7	5	8	11	7	542	119.3	22.31	.000191	41.4	2,470	22.97	5.81	28.78	173	.....
Average..	....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	119.1	.....	.000227	38.2	.....	.....	.....	30.96	186	.....
24..........	Cinder....	1:2:5.06	1:2.02:2.38	19.4	Med..	6	8	8	11	6	467	114.3	32.23	.000284	38.5	5,520	34.22	4.08	38.30	230	.....
28..........	.....do....	1:2.06:5.40	1:2.07:2.54	20.4	...do..	6	6	8	11	6	450	112.9	27.27	.000301	38.3	4,400	27.27	4.05	31.32	188	.....
29..........	.....do....	1:2.06:5.40	1:2.07:2.54	20.4	...do..	6	9	8¼	11	6	478	115.6	19.23	.000120	36.4	3,920	23.56	3.98	27.54	165	.....
Average..	....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	114.3	.....	.000235	37.7	.....	.....	.....	32.39	194	.....
37..........	Cinder....	1:2:5.19	1:2.01:2.44	19.0	Damp	6	6	8¼	11	6	460	111.9	26.44	.000297	36.9	4,400	26.44	4.01	30.45	183	7
38..........	.....do....	1:2:5.19	1:2.01:2.44	19.0	...do..	8	0	8	11¼	7½	578	115.5	24.89	.000234	38.9	2,440	25.30	6.29	31.59	190	12
39..........	.....do....	1:2:5.19	1:2.01:2.44	19.0	...do..	7	0	8	11⅛	6½	506	115.1	27.26	.000229	39.6	3,880	29.53	4.84	34.37	206	24
Average..	....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	114.2	.....	.000253	38.5	.....	.....	.....	32.14	193	.....
53..........	Granite...	1:2:4	1:2.01:3.82	9.2	Wet..	7	7	8$\frac{1}{16}$	11⅛	6½	712	150.2	52.61	.000093	43.8	7,950	59.76	6.04	65.80	395	0
54..........	.....do....	1:2:4	1:2.01:3.82	9.0	..do...	7	0	7$\frac{15}{16}$	11¼	6½	630	144.8	52.26	.000079	51.5	8,000	59.72	5.88	65.60	394	12
55..........	.....do....	1:2:4	1:2.01:3.82	9.0	...do..	6	6	8	11	6	585	144.9	49.58	.000075	47.6	9,000	55.79	5.20	60.99	366	.....
Average..	....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	146.6	.....	.000082	47.6	.....	.....	.....	64.13	385	.....
51..........	Granite...	1:2:4	1:2.01:3.80	7.3	Med..	8	0	8	11⅛	7	732	145.7	63.63	.000090	47.5	8,000	72.72	6.93	79.65	478	5
64..........	.....do....	1:2:4	1:2.01:3.82	8.4	...do..	7	2	8$\frac{1}{16}$	11$\frac{1}{16}$	6½	656	147.3	60.95	.000097	45.2	9,000	68.60	6.06	74.66	448	8
65..........	.....do....	1:2:4	1:2.01:3.82	8.4	...do..	8	1	8⅛	11⅛	7	771	153.8	62.65	.000100	49.1	8,000	71.60	7.06	78.66	472	19
Average..	....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	148.9	.....	.000096	47.3	.....	.....	.....	77.66	466	.....
72..........	Granite...	1:2:4	1:2.01:3.82	6.9	Damp	7	2	8	10⅞	6½	639	147.2	71.34	.000132	45.0	10,000	79.25	6.16	85.41	512	2
73..........	.....do....	1:2:4	1:2.01:3.82	6.9	...do..	6	8	8	11	6	626	149.8	74.38	.000129	45.0	13,000	80.58	5.39	85.97	516	5
78..........	.....do....	1:2:4	1:2.01:3.82	6.9	...do..	7	2	8	11$\frac{3}{16}$	6½	673	150.8	74.90	.000125	44.7	11,000	82.39	6.12	88.51	531	24
Average..	....	....	....	.....	.....	.....	.....	.....	.....	.....	.....	149.3	.....	.000129	44.9	.....	.....	.....	86.63	520	.....

88	Gravel	1:2:4	1:2.01:4.10	9.5	Wet	7	6	8	11	7	640	139.5	46.49	.000073	44.8	6,000	55.79	6.73	62.52	375	16
89	do	1:2:4	1:2.01:4.10	9.5	do	7	9	8⅛	11¼	7	700	142.3	52.52	.000093	42.6	6,000	52.52	6.65	59.17	355	6
90	do	1:2:4	1:2.01:4.10	9.7	do	7	2	8 1/16	11 1/16	6½	634	142.6	45.62	.000063	47.7	7,000	53.22	5.87	59.09	355	6
Average												141.5		.000076	45.0				60.26	362	
100	Gravel	1:2:4	1:2.01:4.10	8.6	Med	7	10	8⅛	11⅛	7	687	142.4	62.72	.000097	44.1	8,390	75.17	6.59	81.76	491	8
101	do	1:2:4	1:2.01:4.10	8.6	do	6	7	8⅛	11 3/16	6	572	137.8	53.10	.000081	45.5	9,000	53.10	4.78	57.88	347	17
102	do	1:2:4	1:2.01:4.10	9.0	do	7	9	8 1/16	11 1/16	7	692	145.5	63.86	.000105	39.1	7,000	63.86	6.85	70.66	424	16
Average												141.9		.000094	42.9				70.10	421	
112	Gravel	1:2:4	1:2.01:4.10	7.6	Damp	7	1	8⅛	11	6½	605	139.3	61.04	.000114	43.6	8,000	61.04	5.71	66.75	400	14
113	do	1:2:4	1:2.01:4.10	7.6	do	7	0	8	11	6½	619	142.9	61.98	.000114	44.1	8,000	61.98	6.00	67.98	408	2
115	do	1:2:4	1:2.01:4.10	7.6	do	6	6	8 1/16	11	6	555	140.6	84.57	.000129	40.0	11,000	84.57	4.91	89.48	537	5
Average												140.9		.000119	42.6				74.74	448	
128	Limestone	1:2:4	1:2.01:3.91	10.8	Wet	7	2	8 1/16	11 1/16	6½	645	145.0	60.82	.000101	50.0	8,660	65.84	5.96	71.80	431	7
129	do	1:2:4	1:2.01:3.91	10.8	do	6	11	8	11¼	6	612	139.1	71.11	.000112	49.1	12,000	71.11	4.82	75.93	456	19
130	do	1:2:4	1:2.01:3.91	11.0	do	6	11	8	11⅜	6	623	142.0	57.96	.000105	43.2	10,930	63.34	4.79	68.13	409	3
Average												142.0		.000106	47.4				71.95	432	
141	Limestone	1:2:4	1:2.01:3.91	10.0	Med	7	0	8 1/16	11 1/16	6½	630	143.2	68.42	.000130	47.3	9,720	73.88	5.99	79.87	479	15
142	do	1:2:4	1:2.01:3.91	10.0	do	7	9	8 1/16	11 1/16	7	698	146.1	63.86	.000102	50.0	8,000	72.98	6.91	79.89	479	9
143	do	1:2:4	1:2.01:3.91	10.0	do	6	9	8	11 1/16	6	608	147.8	73.54	.000145	42.7	12,000	73.54	5.11	78.65	472	1
Average												145.7		.000126	46.7				79.47	477	
150	Limestone	1:2:4	1:2.01:3.91	8.4	Damp	6	11	8 1/16	11⅛	6	623	144.2	84.18	.000138	44.5	15,000	90.19	4.97	95.16	571	14
151	do	1:2:4	1:2.01:3.91	8.4	do	6	11	8	10 13/16	6	607	143.2	83.40	.000145	45.0	13,000	83.40	5.17	88.57	531	9
152	do	1:2:4	1:2.01:3.91	8.4	do	7	9	8	10 15/16	7	686	143.5	65.84	.000120	46.8	8,000	75.24	7.00	82.29	494	16
Average												143.6		.000134	45.4				88.67	532	

TABLE 9.—*Tests of concrete beams of variable span*—Continued.

TESTED AT THIRTEEN WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Dimensions of beam.				Span (ft.).	Weight (pounds).		Final deformeters.			Maximum applied.		Own weight + deformeters $\frac{M}{bd^2}$ (center).	Maximum total $\frac{M}{bd^2}$ (center).	Modulus of rupture $\frac{6M}{bd^2}$	Distance of break from center (inches).
		Volume.	Weight.			Length.		Section (inches).			Total.	Per cubic foot.	$\frac{M}{bd^2}$ (total).	Unit elongation, lower outer fiber.	Position neutral axis.	Load.	$\frac{M}{bd^2}$ (center).				
						Ft.	In.	Wide.	Deep.												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
2	Cinder	1:2:4.86	1:2.02:2.29	22.15	Wet	7	9	8⅛	11 3/16	7	572	118.4	31.87	0.000121	44.1	4,000	35.41	5.54	40.95	246	20
8	do	1:2:4.79	1:2.02:2.25	22.3	do	7	8	8	11	7	554	116.6	29.75	.000165	40.8	3,600	33.47	5.72	39.19	235	11
9	do	1:2:4.79	1:2.02:2.25	22.0	do	8	3	8	11⅛	7½	590	115.3	33.94	.000248	35.0	3,460	36.70	6.34	43.04	258	18
Average												116.8		.000178	40.0				41.06	246	
3	Cinder	1:2:5.13	1:2.02:2.41	21.4	Med	7	4	8¼	11	6½	519	114.2	33.57	.000178	41.3	4,800	36.62	4.73	41.35	248	19
33	do	1:2:5.21	1:2.01:2.45	21.0	do	7	3	8⅛	11 1/16	6½	513	114.8	27.16	.000203	40.2	4,000	30.17	4.69	34.86	209	20
34	do	1:2:5.21	1:2.01:2.45	20.0	do	6	8	8	11⅛	6	477	114.4	33.93	.000340	30.9	5,600	33.93	4.07	38.00	228	12
Average												114.5		.000240	37.5				38.07	228	
40	Cinder	1:2:5.19	1:2.01:2.44	19.0	Damp	8	1	8	11 3/16	7½	584	114.3	33.55	.000275	36.8	3,200	33.55	6.36	39.91	239	4
41	do	1:2:5.19	1:2.01:2.44	19.0	do	7	9	8	11	7	560	116.8	33.47	.000446	30.4	3,600	33.47	5.70	39.17	235	1
42	do	1:2:5.19	1:2.01:2.44	18.9	do	6	9	8	11	6	483	115.9	29.75	.000276	36.9	5,200	32.23	4.15	36.38	218	10
Average												115.7		.000332	34.7				38.49	231	
56	Granite	1:2:4	1:2.01:3.82	8.7	Wet	7	10	8¼	11 3/16	7	723	149.1	70.80	.000092	48.1	9,000	79.65	6.84	86.49	519	6
57	do	1:2:4	1:2.01:3.82	8.7	do	6	9	8	11	6	623	149.7	74.38	.000098	48.6	12,700	78.72	5.29	84.01	504	0
58	do	1:2:4	1:2.01:3.82	9.0	do	7	0	8 1/16	11 1/16	6½	646	148.7	76.02	.000131	46.5	10,000	76.02	6.14	82.16	493	9
Average												149.2		.000107	47.7				84.22	505	
68	Granite	1:2:4	1:2.01:3.82	8.2	Med	8	0	8 1/16	11⅜	7½	763	149.2	70.46	.000104	45.1	7,590	76.40	7.25	83.65	502	10
69	do	1:2:4	1:2.01:3.82	8.2	do	6	11	8	11½	6	660	151.9	79.39	.000126	43.1	14,000	79.39	4.96	84.35	506	14
70	do	1:2:3.97	1:2.01:3.78	8.6	do	6	10	8 1/16	11⅜	6	563	145.0	82.60	.000123	45.9	15,630	86.07	4.20	90.27	542	20
Average												148.7		.000118	44.7				86.09	517	
79	Granite	1:2:4	1:2.01:3.82	6.9	Damp	7	10	8	11	7	699	144.5	83.68	.000129	46.5	10,000	92.98	6.96	99.94	600	21
80	do	1:2:4	1:2.01:3.82	7.0	do	7	3	8 1/16	11 5/16	6½	669	146.9	87.22	.000145	42.9	13,000	94.50	5.83	100.33	602	0
81	do	1:2:4	1:2.01:3.82	7.0	do	6	6	7 15/16	10 15/16	6	580	143.9	82.14	.000147	44.2	14,000	88.46	5.26	93.72	562	5
Average												145.1		.000140	44.5				98.00	588	

91	Gravel	1:2:4	1:2.01:4.10	9.7	Wet	7	0	7 15/16	11⅜	6½	625	141.9	51.12	.000067	48.0	7,000	51.12	5.71	56.83	341	4
92	do	1:2:4	1:2.01:4.10	9.9	do	8	6	8	11⅛	8	758	145.2	60.60	.000088	46.4	5,570	67.52	8.95	76.47	459	2
93	do	1:2:4	1:2.01:4.10	9.9	do	7	5	8	11 3/16	6½	668	143.7	59.92	.000081	48.9	9,000	67.41	5.83	73.24	439	0
Average												143.6		.000079	47.8				68.85	413	
103	Gravel	1:2:4	1:2.01:4.10	9.0	Med	7	8	8	11	7	690	146.5	74.38	.000121	42.2	8,000	74.38	7.05	81.43	489	21
104	do	1:2:4	1:2.01:4.10	9.0	do	7	2	8	11 3/16	6½	634	143.6	67.41	.000082	48.4	10,000	74.90	5.78	80.68	484	15
105	do	1:2:4	1:2.01:4.10	9.0	do	6	8	8	11	6	585	143.3	74.38	.000116	45.1	12,000	74.38	5.05	79.43	477	22
Average												144.5		.000106	45.2				80.51	483	
116	Gravel	1:2:4	1:2.01:4.10	7.6	Damp	6	10	8	11	6	599	142.7	68.19	.000159	38.0	12,000	74.39	5.01	79.40	476	8
117	do	1:2:4	1:2.01:4.10	8.0	do	6	9	7 15/16	11 1/16	6	597	145.0	74.12	.000094	48.6	13,000	80.30	5.06	85.36	512	20
118	do	1:2:4	1:2.01:4.10	8.1	do	8	6	8	10⅞	8	732	144.1	63.42	.000082	48.4	5,960	75.60	9.05	84.65	508	6
Average												143.9		.000112	45.0				83.14	499	
131	Limestone	1:2:4	1:2.01:3.91	11.0	Wet	6	11	8¼	11	6	633	147.6	73.24	.000101	49.5	13,000	79.35	5.12	84.47	507	22
132	do	1:2:4	1:2.01:3.91	11.0	do	7	4	7 15/16	11⅛	6½	660	147.7	83.99	.000121	46.2	11,000	83.99	5.96	89.95	540	14
133	do	1:2:4	1:2.01:3.91	11.0	do	8	1	8	11 3/16	7½	734	146.6	62.91	.000095	46.1	6,950	72.88	7.91	80.79	485	16
Average												147.3		.000106	47.3				85.07	510	
126	Limestone	1:2:4	1:2.01:3.91	10.4	Med	6	6	8	11	6	575	143.5	80.58	.000113	51.8	13,000	80.58	5.12	85.70	514	9
127	do	1:2:4	1:2.01:3.91	10.4	do	6	9	8	11 3/16	6	623	146.4	83.89	.000127	48.3	14,000	83.89	5.11	89.00	534	0
140	do	1:2:4	1:2.01:3.91	10.0	do	7	4	7 15/16	11¼	6½	660	146.1	74.66	.000105	50.0	10,640	79.43	5.82	85.25	512	7
Average												145.3		.000115	50.0				86.65	520	
153	Limestone	1:2:4	1:2.01:3.91	8.4	Damp	7	4	7 15/16	10 15/16	6½	649	144.0	78.98	.000147	42.6	10,000	78.98	6.06	85.04	510	17
154	do	1:2;4	1:2.01:3.91	8.4	do	8	4	7 15/16	11	7½	737	146.1	76.53	.000137	44.8	7,000	76.53	7.99	84.52	507	3
155	do	1:2:4	1:2.01:3.91	8.4	do	7	9	8 1/16	11	7	692	146.3	73.80	.000112	47.6	8,000	73.80	6.93	80.73	484	18
Average												145.5		.000132	45.0				83.43	501	

TABLE 9.—*Tests of concrete beams of variable span*—Continued.

TESTED AT TWENTY-SIX WEEKS.

Register No.	Aggregate.	Proportion. Volume.	Proportion. Weight.	Water (per cent).	Consistency.	Dimensions of beam. Length. Ft.	Dimensions of beam. Length. In.	Dimensions of beam. Section (inches). Wide.	Dimensions of beam. Section (inches). Deep.	Span (ft.).	Weight (pounds). Total.	Weight (pounds). Per cubic foot.	Final deformeters. $\frac{M}{bd^2}$ (total).	Final deformeters. Unit elongation, lower outer fiber.	Final deformeters. Position neutral axis.	Maximum applied. Load.	Maximum applied. $\frac{M}{bd^2}$ (center).	Own weight + deformeters $\frac{M}{bd^2}$ (center).	Maximum total $\frac{M}{bd^2}$ (center).	Modulus of rupture $\frac{6M}{bd^2}$.	Distance of break from center (inches).
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
12	Cinder	1:2:4.79	1:2.02:2.25	22.4	Wet	6	11	8 1/16	11 1/16	6	495	115.9	39.52	0.000266	38.0	6,670	40.56	4.04	44.60	268	21
15	do	1:2:4.79	1:2.02:2.25	22.4	do	7	5	8	10 7/8	6½	513	114.2	35.67	.000171	44.2	5,060	39.63	4.80	44.43	267	21
16	do	1:2:5.06	1:2.02:2.38	21.3	do	6	8	7 15/16	11	6	467	112.8	40.60	.000259	40.6	6,500	40.60	4.11	44.71	268	16
Average												114.3		.000232	40.9				44.58	268	
5	Cinder	1:2:4.79	1:2.02:2.25	21.7	Med	7	0	8 1/16	11 3/16	6	506	117.2	48.31	.000232	43.5	6,500	48.31	4.75	53.06	318	11
6	do	1:2:4.79	1:2.02:2.25	21.7	do	7	4	8 1/16	11	6½	525	116.0	38.44	.000193	42.9	5,500	42.28	4.82	47.10	283	9
35	do	1:2:5.21	1:2.01:2.45	20.0	do	6	10	8	11	6	489	116.1	34.10	.000211	40.4	5,600	34.71	4.13	38.84	233	24
Average												116.4		.000212	42.3				46.33	278	
43	Cinder	1:2:5.19	1:2.01:2.44	19.0	Damp	7	0	8⅛	11 1/16	6½	490	111.3	41.48	.000327	39.0	5,600	42.24	4.68	46.92	282	17
44	do	1:2:5.19	1:2.01:2.44	19.0	do	7	0	8⅛	11⅛	6½	495	114.0	37.29	.000264	39.2	5,350	39.90	4.67	44.57	267	3
45	do	1:2:5.19	1:2.01:2.44	18.5	do	6	10	8⅛	11 1/16	6	478	111.8	39.22	.000290	38.1	6,500	39.22	3.94	43.16	259	14
Average												112.4		.000294	38.8				44.88	269	
59	Granite	1:2:4	1:2.01:3.82	9.0	Wet	8	4	8 1/16	11 5/16	7½	782	145.2	81.42	.000124	47.8	8,000	81.42	7.87	89.29	536	0
60	do	1:2:4	1:2.01:3.82	8.8	do	6	9	7⅞	11 7/16	6	639	151.9	81.56	.000114	46.4	14,950	87.09	5.09	92.18	553	8
61	do	1:2:4	1:2.01:3.82	9.0	do	6	7	8	11⅛	6	623	150.3	78.78	.000121	45.8	13,550	82.11	5.33	87.44	525	19
Average												149.1		.000120	46.7				89.64	538	
71	Granite	1:2:3.97	1:2.01:3.78	8.6	Med	7	2	8 1/16	11 7/16	6½	689	149.4	85.36	.000112	48.0	12,000	85.36	5.95	91.31	548	22
74	do	1:2:4	1:2.01:3.82	8.4	do	7	9	8 1/16	11 3/16	7	727	150.5	89.18	.000132	45.0	10,000	89.18	7.02	96.20	577	15
75	do	1:2:4	1:2.01:3.82	8.4	do	6	8	8	11 3/16	6	615	147.0	83.90	.000130	44.5	14,000	83.90	5.12	89.02	534	22
Average												149.0		.000125	45.8				92.18	553	
82	Granite	1:2:4	1:2.01:3.82	7.0	Damp	8	1	8 1/16	11 1/16	7½	740	147.5	85.13	.000123	47.1	8,900	94.70	8.09	102.79	617	16
83	do	1:2:4	1:2.01:3.82	7.0	do	7	9	8⅛	11⅛	7	709	146.1	80.56	.000123	42.8	10,000	89.50	6.88	96.28	578	7
84	do	1:2:4	1:2.01:3.82	7.1	do	6	10	8 1/16	11 5/16	6	647	146.9	87.22	.000132	45.8	15,550	90.42	5.06	95.48	573	16
Average												146.8		.000126	45.2				98.22	589	

94	Gravel	1:2:4	1:2.01:4.10	9.9	Wet	7	8	8 1/16	11 3/8	7	678	136.4	69.02	.000087	51.9	9,000	77.64	6.43	84.07	504	6
95	do	1:2:4	1:2.01:4.10	9.9	do	7	8	8	11 5/16	7	672	139.0	70.32	.000096	48.2	8,000	70.32	6.50	76.82	461	14
96	do	1:2:4	1:2.01:4.10	9.9	do	7	8	8⅛	11 5/16	7	690	140.5	60.59	.000097	43.5	7,000	60.59	6.57	67.16	403	10
Average												138.6		.000093	47.9				76.02	456	
106	Gravel	1:2:4	1:2.01:4.10	9.1	Med.	6	10	8	11 1/16	6	599	142.1	67.42	.000094	47.6	12,000	73.55	4.96	78.51	471	17
107	do	1:2:4	1:2.01:4.10	9.1	do	6	7	8	11	6	582	138.0	80.58	.000114	45.5	14,000	86.78	5.10	91.88	551	16
108	do	1:2:4	1:2.01:4.10	9.0	do	7	8	8	11⅛	7	684	142.7	63.63	.000090	45.9	7,920	72.00	6.84	78.84	473	5
Average												140.9		.000099	46.3				83.08	498	
119	Gravel	1:2:4	1:2.01:4.10	8.1	Damp.	6	10	8 1/16	10 15/16	6	599	141.5	74.65	.000100	49.5	12,620	78.50	5.03	83.53	501	8
120	do	1:2:4	1:2.01:4.10	8.1	do	6	9	8 1/16	11	6	592	140.7	67.65	.000105	49.2	11,850	72.88	5.00	77.88	467	3
121	do	1:2:4	1:2.01:4.10	8.1	do	7	3	8⅛	11 1/16	6	636	141.8	75.43	.000119	44.0	10,900	82.22	5.79	88.01	528	14
Average												141.3		.000108	47.6				83.14	499	
134	Limestone	1:2:4	1:2.01:3.91	11.0	Wet	6	7	8 1/16	11⅛	6	603	146.4	66.14	.000100	50.5	12,000	72.15	5.12	77.27	464	4
135	do	1:2:4	1:2.01:3.91	11.0	do	9	0	8	11¼	8	824	144.5	59.26	.000092	49.1	6,000	71.12	8.87	79.99	480	14
136	do	1:2:4	1:2.01:3.91	11.0	do	7	8	8	11¼	7	702	145.8	71.11	.000105	48.3	9,000	80.00	6.85	86.85	521	6
Average												145.6		.000099	49.3				81.37	488	
144	Limestone	1:2:4	1:2.01:3.91	10.0	Med.	7	3	8 1/16	11⅛	6½	658	144.0	82.68	.000118	48.1	12,000	90.20	5.93	96.13	577	9
145	do	1:2:4	1:2.01:3.91	10.0	do	8	0	8	11 3/16	7½	732	146.7	73.41	.000108	47.1	8,000	83.90	7.98	91.88	551	16
258	do	1:2:4	1:2.01:3.91	10.0	do	8	5	8 1/16	11 5/16	7½	770	145.1	81.41	.000102	51.6	8,000	81.41	7.66	89.07	534	6
Average												145.3		.000109	48.9				92.36	554	
158	Limestone	1:2:4	1:2.01:3.91	8.6	Damp.	6	8	8	11⅛	6	621	149.2	84.84	.000127	47.5	15,000	90.90	5.23	96.13	577	21
259	do	1:2:4	1:2.01;3.91	8.6	do	8	3	8 1/16	11¼	7½	762	149.4	92.61	.000128	48.6	9,000	92.61	7.86	100.47	603	0
260	do	1:2:4	1:2.01:3.91	8.6	do	6	7	8 1/16	11⅛	6	613	147.3	97.41	.000137	47.4	16,200	97.41	5.20	102.61	616	14
Average												148.6		.000131	47.8				99.74	632	

TABLE 10.—*Compression tests of concrete cylinders and cubes accompanying beams.*

TESTED AT FOUR WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Cylinders.						Cubes.				Stress ratio of cylinders to cubes.
		Volume.	Weight.			Dimensions (inches).		Weight (pounds per cubic foot).	Maximum unit stress.	Initial modulus of elasticity.	Range of linear values.	Dimensions (inches).		Weight (pounds per cubic foot).	Maximum unit stress.	
						Diameter.	Length.					Base.	Height.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
18	Cinder	1:2:5.06	1:2.02:2.38	21.6	Wet	8.00	16.00	....	1,243	1,017,000	200	6.00×6.00	5.94	....	1,394	0.892
19	do	1:2:5.06	1:2.02:2.38	21.8	do	8.00	16.00	....	1,000	1,337,000	250	6.00×6.00	5.94	....	1,200	.833
21	do	1:2:5.06	1:2.02:2.38	21.6	do	8.00	16.00	....	1,000	1,355,000	350	6.00×6.00	6.00	....	1,173	.853
Average								....	1,081	1,236,000	270			....	1,256	.859
24	Cinder	1:2:5.06	1:2.02:2.38	19.4	Med	8.00	16.00	....	1,114	2,020,000	250	6.00×6.00	6.00	....	1,179	.945
28	do	1:2.06:5.40	1:2.07:2.54	20.4	do	8.00	16.00	....	1,250	1,000,000	250	6.00×6.00	6.25	....	1,093	1.144
29	do	1:2.06:5.40	1:2.07:2.54	20.4	do	8.00	16.00	....	1,240	1,035,000	300	6.00×6.00	6.13	....	1,302	.952
Average								....	1,201	1,352,000	270			....	1,191	1.014
37	Cinder	1:2:5.19	1:2.01:2.44	19.0	Damp	8.00	16.00	....	1,055	1,250,000	300	6.00×6.00	6.13	....	1,541	.685
38	do	1:2:5.19	1:2.01:2.44	19.0	do	8.00	16.00	....	1,210	1,390,000	250	6.00×6.00	6.13	....	1,394	.868
39	do	1:2:5.19	1:2.01:2.44	19.0	do	8.00	16.00	....	1,090	1,225,000	350	6.00×6.00	6.13	....	1,199	.909
Average								....	1,118	1,288,000	300			....	1,378	.821
53	Granite	1:2:4	1:2.01:3.82	9.2	Wet	8.00	16.00	149.3	3,093	3,690,000	700	6.00×6.00	6.00	144.0	3,318	.932
54	do	1:2:4	1:2.01:3.82	9.0	do	8.00	16.00	146.6	2,350	3,020,000	850	6.00×6.00	6.13	146.0	3,151	.746
55	do	1:2:4	1:2.01:3.82	9.0	do	8.00	16.00	150.4	2,607	4,000,000	800	6.00×6.00	6.13	148.9	3,000	.869
Average								148.8	2,683	3,570,000	780			146.3	3,156	.849
51	Granite	1:2:4	1:2.01:3.82	7.3	Med	8.00	16.00	150.9	3,990	4,100,000	1,000	6.00×6.00	6.00	153.0	4,063	.982
64	do	1:2:4	1:2.01:3.82	8.4	do	7.99	16.05	148.8	3,250	4,640,000	800	6.02×6.02	6.13	147.8	4,251	.765
65	do	1:2:4	1:2.01:3.82	8.4	do	8.07	16.19	146.6	3,199	3,510,000	1,000	6.03×6.03	6.14	146.1	3,954	.809
Average								148.8	3,480	4,083,000	930			149.0	4,089	.852
72	Granite	1:2:4	1:2.01:3.82	6.9	Damp	8.03	15.95	149.8	4,000	4,840,000	1,000	5.98×5.98	6.06	150.5	5,072	.789
73	do	1:2:4	1:2.01:3.82	6.9	do	8.04	16.14	148.7	4,000	4,860,000	1,000	6.03×6.03	6.05	147.3	3,780	1.058
78	do	1:2:4	1:2.01:3.82	6.9	do	8.02	15.97	148.9	4,000	4,960,000	950	5.99×5.99	6.03	145.8	4,703	.851
Average								149.1	4,000	4,890,000	980			147.9	4,518	.899
88	Gravel	1:2:4	1:2.01:4.10	9.5	Wet	8.02	16.24	141.1	2,336	3,850,000	800	5.98×5.98	6.18	141.7	2,757	.847
89	do	1:2:4	1:2.01:4.10	9.5	do	7.99	16.11	138.2	2,087	4,040,000	1,000	6.02×6.02	6.23	138.5	2,342	.891
90	do	1:2:4	1:2.01:4.10	9.7	do	7.99	16.22	141.6	1,758	3,470,000	800	6.04×6.04	6.22	139.0	1,799	.977
Average								140.3	2,060	3,787,000	870			139.7	2,299	.905

100	Gravel	1:2:4	1:2.01:4.10	8.6	Med.	8.06	16.09	142.6	3,375	a 6,620,000	1,500	6.02×6.02	6.12	142.1	3,886	.889
101	do	1:2:4	1:2.01:4.10	8.6	do	7.99	16.18	142.7	2,486	3,900,000	1,500	5.97×5.97	6.14	146.1	3,576	.695
102	do	1:2:4	1:2.01:4.10	9.0	do	7.99	16.18	142.7	3,022	3,850,000	1,500	6.02×6.02	6.16	142.2	3,179	.951
Average								142.7	2,961	3,875,000	1,500			143.5	3,547	.838
112	Gravel	1:2:4	1:2.01:4.10	7.6	Damp	8.09	16.04	141.7	3,437	4,640,000	1,000	6.02×6.02	6.09	142.9	4,581	.750
113	do	1:2:4	1:2.01:4.10	7.6	do	8.11	16.15	140.9	a 2,392	3,840,000	1,200	6.03×6.03	6.07	144.9	4,565	
115	do	1:2:4	1:2.01:4.10	7.6	do	8.07	16.08	142.9	3,377	3,730,000	1,400	5.97×5.97	6.02	147.1	4,689	.720
Average								141.8	3,407	4,070,000	1,200			145.0	4,612	.735
128	Limestone	1:2:4	1:2.01:3.91	10.8	Wet	7.99	16.02	147.6	2,741	3,460,000	900	6.06×6.06	6.16	142.3	5,065	.541
129	do	1:2:4	1:2.01:3.91	10.8	do	8.02	16.07	145.5	2,591	3,890,000	1,300	5.99×5.99	6.14	147.1	5,216	.497
130	do	1:2:4	1:2.01:3.91	11.0	do	8.07	16.04	143.2	3,884	3,415,000	1,200	5.98×5.98	6.23	145.5	a 2,307	a 1.684
Average								145.4	3,072	3,588,000	1,130			145.0	5,141	.519
141	Limestone	1:2:4	1:2.01:3.91	10.0	Med.	7.99	16.11	145.5	3,889	3,400,000	700	5.98×5.98	6.12	146.1	2,644	1.471
142	do	1:2:4	1:2.01:3.91	10.0	do	7.97	16.08	145.9	2,458	3,700,000	800	6.02×6.02	6.04	143.8	3,315	.742
143	do	1:2:4	1:2.01:3.91	10.0	do	8.01	16.04	146.6	2,382	3,195,000	1,100	6.01×6.02	6.14	143.9	2,965	.803
Average								146.0	2,910	3,432,000	870			144.6	2,975	1.005
151	Limestone	1:2:4	1:2.01:3.91	8.4	Damp	8.03	16.22	146.2	3,171	4,025,000	800	6.03×6.03	6.07	147.8	3,948	.803
152	do	1:2:4	1:2.01:3.91	8.4	do	7.98	16.07	150.8	2,749	4,720,000	500	5.99×5.99	6.05	149.3	4,392	.626
153	do	1:2:4	1:2.01:3.91	8.4	do	8.04	16.12	149.0	2,761	4,025,000	1,200	5.98×5.98	6.06	148.5	4,760	.580
Average								148.7	2,894	4,257,000	830			148.5	4,367	.670

a Not included in average.

TABLE 10.—*Compression tests of concrete cylinders and cubes accompanying beams*—Continued.

TESTED AT THIRTEEN WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Cylinders.						Cubes.				Stress ratio of cylinders to cubes.
		Volume.	Weight.			Dimensions (inches). Diameter.	Dimensions (inches). Length.	Weight (pounds per cubic foot).	Maximum unit stress.	Initial modulus of elasticity.	Range of linear values.	Dimensions (inches). Base.	Dimensions (inches). Height.	Weight (pounds per cubic foot).	Maximum unit stress.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	Cinder	1:2:4.86	1:2.02:2.29	22.15	Wet	8.02	16.00	120.3	1,651	3,500,000	400	6.04×6.04	6.04	115.7	2,037	0.311
8	do	1:2:4.79	1:2.02:2.25	22.3	do	8.02	15.88	117.2	1,963	1,740,000	600	6.04×6.04	6.09	114.8	2,086	.941
9	do	1:2:4.79	1:2.02:2.25	22.0	do	8.01	16.13	111.9	1,678	2,730,000	300	6.02×6.03	6.01	115.8	1,923	.873
Average								116.5	1,764	2,657,000	430			115.4	2,015	.875
3	Cinder	1:2:5.13	1:2.02:2.41	21.4	Med	8.01	15.75	118.7	1,830	3,120,000	400	6.07×6.07	6.04	112.6	1,687	1.085
33	do	1:2:5.21	1:2.01:2.45	21.0	do	8.00	15.99	114.5	1,643	2,030,000	300	5.99×6.04	6.04		2,145	.766
34	do	1:2:5.21	1:2.01:2.45	20.0	do	8.01	16.02	113.7	1,984	1,675,000	500	6.11×6.12	6.07	110.3	1,732	1.146
Average								115.6	1,819	2,275,000	400			111.5	1,855	.999
40	Cinder	1:2:5.19	1:2.01:2.44	19.0	Damp	8.00	16.15	113.6	1,725	1,940,000	500	5.97×6.05	6.07	114.3	2,009	.859
41	do	1:2:5.19	1:2.01:2.44	19.0	do	8.06	16.15	112.5	1,790	1,460,000	400	6.03×6.06	6.15	114.4	1,806	.991
42	do	1:2:5.19	1:2.01:2.44	18.9	do	8.07	16.03	111.4	1,662	1,505,000	500	5.99×6.03	6.15	114.8	1,769	.940
Average								112.5	1,726	1,635,000	470			114.5	1,861	.930
56 [a]	Granite	1:2:4	1:2.01:3.82	8.7	Wet	8.00	16.10	146.6	3,528	4,840,000	1,300	6.04×6.05	6.27	145.2	4,779	.738
57	do	1:2:4	1:2.01:3.82	8.7	do	8.07	16.15	144.9	3,197	3,690,000	1,200	6.05×6.07	6.25	145.0	4,954	.645
58	do	1:2:4	1:2.01:3.82	9.0	do	7.99	16.00	146.7	3,805	4,320,000	1,300	6.01×6.03	6.04	148.0	4,529	.840
Average								146.1	3,510	4,283,000	1,270			146.1	4,754	.741
68	Granite	1:2:4	1:2.01:3.82	8.2	Med	8.00	16.13	147.9	(b)	4,800,000	1,100	6.02×6.06	6.20	149.9	5,099	
69	do	1:2:4	1:2.01:3.82	8.2	do	8.03	16.24	145.8	(c)	4,780,000	1,200	6.01×6.01	6.14	148.0	5,372	
70	do	1:2:3.97	1:2.01:3.78	8.6	do	8.01	16.01	147.5	3,777	4,660,000	1,100	6.03×6.05	6.11	146.3	4,504	
Average								147.1		4.747,000	1,130			148.1	4,992	
79	Granite	1:2:4	1:2.01:3.82	6.9	Damp	8.05	16.09	148.2	(d)	4,340,000	1,300	6.01×6.02	6.12	148.3	(e)	
80	do	1:2:4	1:2.01:3.82	7.0	do	8.03	16.11	148.3	(c)	5,280,000	1,200	5.98×6.02	6.03	149.3	5,445	
81	do	1:2:4	1:2.01:3.82	7.0	do	8.08	16.10	147.6	(f)	4,470 000	1,000	6.02×6.06	6.11	144.4	(g)	
Average								148.0		4,697,000	1,170			147.3		

91	Gravel	1:2:4	1:2.01:4.10	9.7	Wet	8.01	16.37	139.6	2,000	5,300,000	1,000	Cubes not tested.				
92	do	1:2:4	1:2.01:4.10	9.9	do	8.01	16.16	140.9	2,907	5,000,000	1,200					
93	do	1:2:4	1:2.01:4.10	9.9	do	8.03	16.37	139.7	3,105	4,310,000	1,100					
Average								140.1	2,954	4,890,000	1,100					
103	Gravel	1:2:4	1:2.01:4.10	9.0	Med	8.09	16.10	140.7	(h)	5,920,000	900					
104	do	1:2:4	1:2.01:4.10	9.0	do	8.05	16.13	142.3	[i]3,930	5,300,000	1,200					
105	do	1:2:4	1:2.01:4.10	9.0	do	8.03	16.17	141.1	2,765	4,380,000	1,900					
Average								141.4		5,200,000	1,330					
116	Gravel	1:2:4	1:2.01:4.10	7.6	Damp	8.02	16.15	145.1	(j)	5,140,000	1,400	6.03×6.03	6.01		4,071	
117	do	1:2:4	1:2.01:4.10	8.0	do	8.01	16.16	146.4	(k)	5,140,000	1,400	6.05×6.05	6.10		5,369	
118	do	1:2:4	1:2.01:4.10	8.1	do	8.03	16.18	143.4	(c)	5,200,000	1,100	6.02×6.01	6.05		5,528	
Average								145.0		5,160,000	1,300				4.989	
131	Limestone	1:2:4	1:2.01:3.91	11.0	Wet	8.05	16.23	142.0	3,397	3,700,000	1,000	6.10×6.15	6.07	141.3	4,068	.835
132	do	1:2:4	1:2.01:3.91	11.0	do	8.00	16.12	145.0	3,441	4,240,000	700	6.05×6.05	6.17	142.5	4,179	.823
133	do	1:2:4	1:2.01:3.91	11.0	do	7.99	16.10	145.5	3,318	4,010,000	1,000	6.10×6.06	6.15	141.5	3,776	.879
Average								144.2	3,385	3,983,000	900			141.8	4,008	.846
126 [l]	Limestone	1:2:4	1:2.01:3.91	10.4	Med	8.03	16.16	147.0	3,508	3,800,000	1,000	6.02×6.03	6.19	143.3	4,004	.876
127 [l]	do	1:2:4	1:2.01:3.91	10.4	do	8.05	16.11	146.2	3,458	3,960,000	1,100	6.04×6.05	6.19	143.2	3,974	.870
140 [l]	do	1:2:4	1:2.01:3.91	10.0	do	8.02	16.27	143.5	3,445	4,130,000	800	6.03×6.05	6.18	143.7	3,838	.898
Average								145.6	3,470	3,963,000	970			143.4	3,939	.881
153	Limestone	1:2:4	1:2.01:3.91	8.4	Damp	8.02	16.41	146.7	(f)	4,680,000	1,200	6.01×6.11	6.12	146.1	(m)	
154	do	1:2:4	1:2.01:3.91	8.4	do	8.00	16.22	148.3	(b)	4,500,000	1,000	6.02×6.06	6.17	145.9	5,483	
155	do	1:2:4	1:2.01:3.91	8.4	do	8.02	16.20	149.0	(j)	4,800,000	1,000	6.03×6.03	6.13	147.3	5,451	
Average								148.0		4,660,000	1,070			146.4		

---

[a] Cylinder spalled before test.
[b] Cylinder did not fail at 3,979 unit stress.
[c] Cylinder did not fail at 3,950 unit stress.
[d] Cylinder did not fail at 3,929 unit stress.
[e] Cube did not fail at 5,528 unit stress
[f] Cylinder did not fail at 3,900 unit stress.
[g] Cube did not fail at 5,483 unit stress.
[h] Cylinder did not fail at 3,891 unit stress.
[i] Cylinder broke after several minutes under load.
[j] Cylinder did not fail at 3,959 unit stress.
[k] Cylinder did not fail at 3,969 unit stress.
[l] Cubes 17 weeks old.
[m] Cube did not fail at 5,447 unit stress.

TABLE 10.—*Compression tests of concrete cylinders and cubes accompanying beams*—Continued.

TESTED AT TWENTY-SIX WEEKS.

Register No.	Aggregate.	Proportion. Volume.	Proportion. Weight.	Water (per cent).	Consistency.	Cylinders. Dimensions (inches). Diameter.	Cylinders. Dimensions (inches). Length.	Cylinders. Weight (pounds per cubic foot).	Cylinders. Maximum unit stress.	Cylinders. Initial modulus of elasticity.	Cylinders. Range of linear values.	Cubes. Dimensions (inches). Base.	Cubes. Dimensions (inches). Height.	Cubes. Weight (pounds per cubic foot).	Cubes. Maximum unit stress.	Stress ratio of cylinders to cubes.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
12	Cinder	1:2:4.79	1:2.02:2.25	22.4	Wet	7.99	15.95	113.2	1,872	1,720,000	500	6.00×6.00	6.00	114.0	2,350	0.797
15	do	1:2:4.79	1:2.02:2.25	22.4	do	8.00	16.11	113.9	2,090	1,580,000	800	6.00×6.00	6.00	115.0	2,124	.984
16	do	1:2:5.06	1:2.02:2.38	21.3	do	7.98	16.02	114.6	2,100	1,530,000	1,000	6.00×6.00	6.00	115.0	2,486	.845
Average								113.9	2,021	1,610,000	770			114.7	2,320	.875
5	Cinder	1:2:4.79	1:2.02:2.25	21.7	Med	8.01	15.85	113.4	2,481	1,680,000	1,200	6.01×6.03	6.03	115.7	2,950	.841
6	do	1:2:4.79	1:2.02:2.25	21.7	do	7.98	15.91	116.2	2,132	1,535,000	700	6.00×5.99	6.03	116.7	2,633	.810
35	do	1:2:5.21	1:2.01:2.45	20.0	do	8.00	16.10	113.4	1,995	1,640,000	600	6.03×6.03	6.06	111.9	2,712	.736
Average								114.3	2,203	1,618,000	830			114.8	2,765	.796
43	Cinder	1:2:5.19	1:2.01:2.44	19.0	Damp	8.02	16.16	112.2	1,940	1,300,000	700	6.04×6.04	6.02	113.1	2,310	.840
44	do	1:2:5.19	1:2.01:2.44	19.0	do	8.01	16.02	114.2	1,895	1,245,000	600	6.04×6.03	6.14	109.2	2,434	.779
45	do	1:2:5.19	1:2.01:2.44	18.5	do	7.98	16.10	114.8	2,001	1,600,000	600	6.14×6.02	6.02	115.5	2,720	.736
Average								113.7	1,945	1,382,000	630			112.6	2,488	.785
59	Granite	1:2:4	1:2.01:3.82	9.0	Wet	8.03	15.81	147.6	(a)	4,000,000	•2,000	6.03×6.00	6.00	146.3	4,768	
60	do	1:2:4	1:2.01:3.82	8.8	do	7.99	15.90	147.1	(b)	4,040,000	1,400	6.01×6.01	6.03	145.8	4,859	
61	do	1:2:4	1:2.01:3.82	9.0	do	8.02	16.02	149.2	(c)	4,130,000	1,700	6.01×6.02	6.03	157.4	4,633	
Average								148.0		4,057,000	1,700			149.8	4,753	
71	Granite	1:2:3.97	1:2.01:3.78	8.6	Med	8.02	16.08	146.8	(c)	4,020,000	2,000	6.13×6.09	6.00	144.7	4,814	
74	do	1:2:4	1:2.01:3.82	8.4	do	8.00	16.11	147.5	(d)	3,800,000	2,200	6.00×5.98	6.12	149.5	4,892	
75	do	1:2:4	1:2.01:3.82	8.4	do	8.00	16.10	147.1	(d)	3,920,000	2,100	6.06×6.01	6.17	145.2	5,142	
Average								147.1		3,913,000	2,100			146.5	4,949	
82	Granite	1:2:4	1:2.01:3.82	7.0	Damp	8.02	16.11	149.9	(c)	4,760,000	2,000	6.00×6.06	6.00		5,410	
83	do	1:2:4	1:2.01:3.82	7.0	do	8.01	16.11	150.3	(e)	4,310,000	2,300	6.00×6.00	6.08	149.0	(f)	
84	do	1:2:4	1:2.01:3.82	7.1	do	8.00	16.02	149.1	(g)	4,220,000	2,000	6.02×6.02	6.04	147.0	5,519	
Average								149.8		4,430,000	2,100			148.0		
94	Gravel	1:2:4	1:2.01:4.10	9.9	Wet	8.00	16.09	138.4	[h]3,461	4,090,000	1,900	6.00×6.00	6.21	137.2	3,793	.913
95	do	1:2:4	1:2.01:4.10	9.9	do	8.01	16.15	139.1	3,431	3,660,000	2,200	6.05×6.01	6.22	138.5	3,699	.927
96	do	1:2:4	1:2.01:4.10	9.9	do	8.01	16.15	138.3	3,565	4,400,000	1,100	6.00×6.04	6.17	138.1	3,949	.903
Average								138.6	3,486	4,050,000	1,730			137.9	3,814	.914

106	Gravel	1:2:4	1:2.01:4.10	9.1	Med	8.01	16.17	142.4	(e)	4,760,000	2,400	6.00×6.00	6.15	142.5	5,176
107	do	1:2:4	1:2.01:4.10	9.1	do	8.00	16.14	142.7	(g)	4,740,000	(i)	6.03×6.03	6.20	140.9	4,810
108	do	1:2:4	1:2.01:4.10	9.0	do	8.01	16.12	143.9	(c)	4,480,000	2,600	6.06×6.06	6.02	142.6	4,439
Average								143.0		4,660,000	2,500			142.0	4,808
119	Gravel	1:2:4	1:2.01:4.10	8.1	Damp	8.00	16.02	145.9	(d)	5,400,000	2,300	6.00×6.00	6.00	144.0	5,472
120	do	1:2:4	1:2.01:4.10	8.1	do	8.03	16.02	147.0	(a)	4,480,000	1,700	6.00×6.00	6.00	144.0	4,972
121	do	1:2:4	1:2.01:4.10	8.1	do	8.00	16.00	147.5	(g)	4,740,000	2,400	6.00×6.00	6.00	146.0	4,208
Average								146.8		4,873,000	2,130			144.7	4,884
134	Limestone	1:2:4	1:2.01:3.91	11.0	Wet	8.02	16.00	144.3	3,062	3,980,000	1,600	6.00×6.00	6.00	148.0	3,167	.967
135	do	1:2:4	1:2.01:3.91	11.0	do	8.00	16.03	145.8	3,113	3,080,000	1,600	6.00×6.00	6.00	144.0	3,860	.807
136	do	1:2:4	1:2.01:3.91	11.0	do	8.03	16.06	143.4	3,473	3,210,000	1,800	6.00×6.00	6.00	148.0	3,354	1.035
Average								144.5	3,216	3,423,000	1,670			146.7	3,460	.936
144	Limestone	1:2:4	1:2.01:3.91	10.0	Med	8.00	16.05	146.7	3,567	4,030,000	1,500	6.00×6.00	6.00	150.0	3,300	1.081
145	do	1:2:4	1:2.01:3.91	10.0	do	8.02	16.13	145.2	3,902	3,640,000	2,000	6.00×6.00	6.00	148.0	3,443	1.133
258	do	1:2:4	1:2.01:3.91	10.0	do	8.00	16.06	146.8	3,605	4,160,000	1,200	6.01×6.01	6.07	147.3	4,935	.731
Average								146.2	3,691	3,943,000	1,570			148.4	3,896	.982
158	Limestone	1:2:4	1:2.01:3.91	8.6	Damp	8.13	16.13	145.7	(j)	3,690,000	2,000	6.00×6.00	6.00	150.0	4,218	
259	do	1:2:4	1:2.01:3.91	8.6	do	7.99	16.19	149.0	(b)	4,400,000	1,400	5.96×6.05	6.09	148.0	5,325	
260	do	1:2:4	1:2.01:3.91	8.6	do	8.00	16.19	148.4	(d)	4,220,000	1,900	6.01×5.99	6.03	147.8	5,532	
Average								147.7		4,310,000	1,770			148.6	5,025	

---

[a] Cylinder did not break at 3,950 unit stress.

[b] Cylinder did not break at 3,989 unit stress.

[c] Cylinder did not break at 3,959 unit stress.

[d] Cylinder did not break at 3,979 unit stress.

[e] Cylinder did not break at 3,969 unit stress.

[f] Cube did not break at 5,556 unit stress.

[g] Cylinder did not break at 3,978 unit stress.

[h] Cylinder stress approximate.

[i] Machine vibrated compressometer.

[j] Cylinder did not break at 3,858 unit stress.

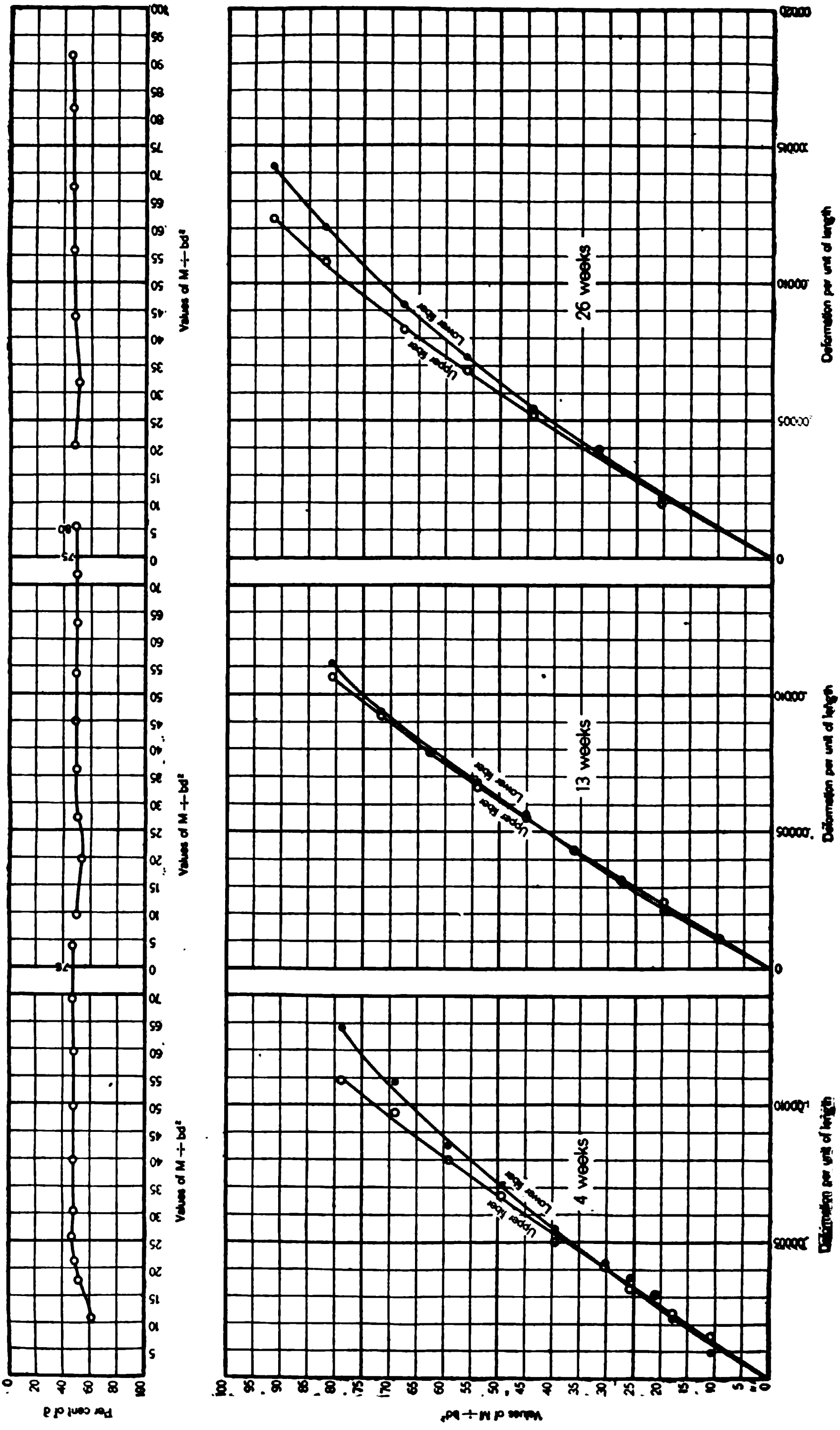


FIG. 11.—Characteristic deformation curves for flexure, granite concrete of medium consistency; ages 4, 13, and 26 weeks.

BEAMS OF VARIABLE SPAN.

The detailed results of tests of the beams of variable span are given in Table 9 (pp. 42–47), and some of the results are graphically shown in figs. 2–5. The information given in columns 1–14, 17, 18, 21, and 22 of the table is identical in character with that given in the corresponding columns of Table 8.

Column 15 contains the unit elongation of the lower outer fiber for the applied load only, since the short beams were not suspended for zero total deformations as were the long beams. The values of the unit elongation, including that due to the weight of the beam and the deformeters, may be approximated by increasing the values in column 15 by an amount obtained from the averages in column 12, Table 8, on the assumption that the elongation is directly proportional to the values for $\frac{M}{bd^2}$, which is approximately true for values below those for the weight of the beam plus the weight of the deformeters. The values for $\frac{M}{bd^2}$ for own weight and deformeters are given in column 19 and, as may be seen by comparing with the maximum total values in column 20, are in the majority of cases but a small percentage of the total.

Column 16 gives the position of the neutral axis in percentage of the depth below the top of the beam. These values are not strictly comparable with those in column 15, Table 8, since they are based on deformations due to the applied load alone.

CYLINDERS AND CUBES.

The detailed results of the compression tests of cylinders 8 inches in diameter by 16 inches in length and of 6-inch cubes are given in Table 10. Some of the results are also graphically shown in figs. 2–9.

Columns 1–6 contain the same kind of information as is given for the beams in the corresponding columns of Tables 8 and 9.

Columns 7 and 8 and columns 13 and 14 show the dimensions of the cylinders and cubes, respectively, in inches.

Columns 9 and 15 show the weight in pounds per cubic foot, as figured from the dimensions and the actual weight of each cylinder and cube when tested.

Columns 10 and 16 show the ultimate strength of each cylinder and cube in pounds per square inch.

The initial modulus of elasticity (given in column 11) was obtained from a curve showing the relation between the unit gross deformation and the compressive stress in pounds per square inch, by drawing a line tangent to the curve at the origin or where possible coincident with the straight line or initial part of the curve. The range in pounds

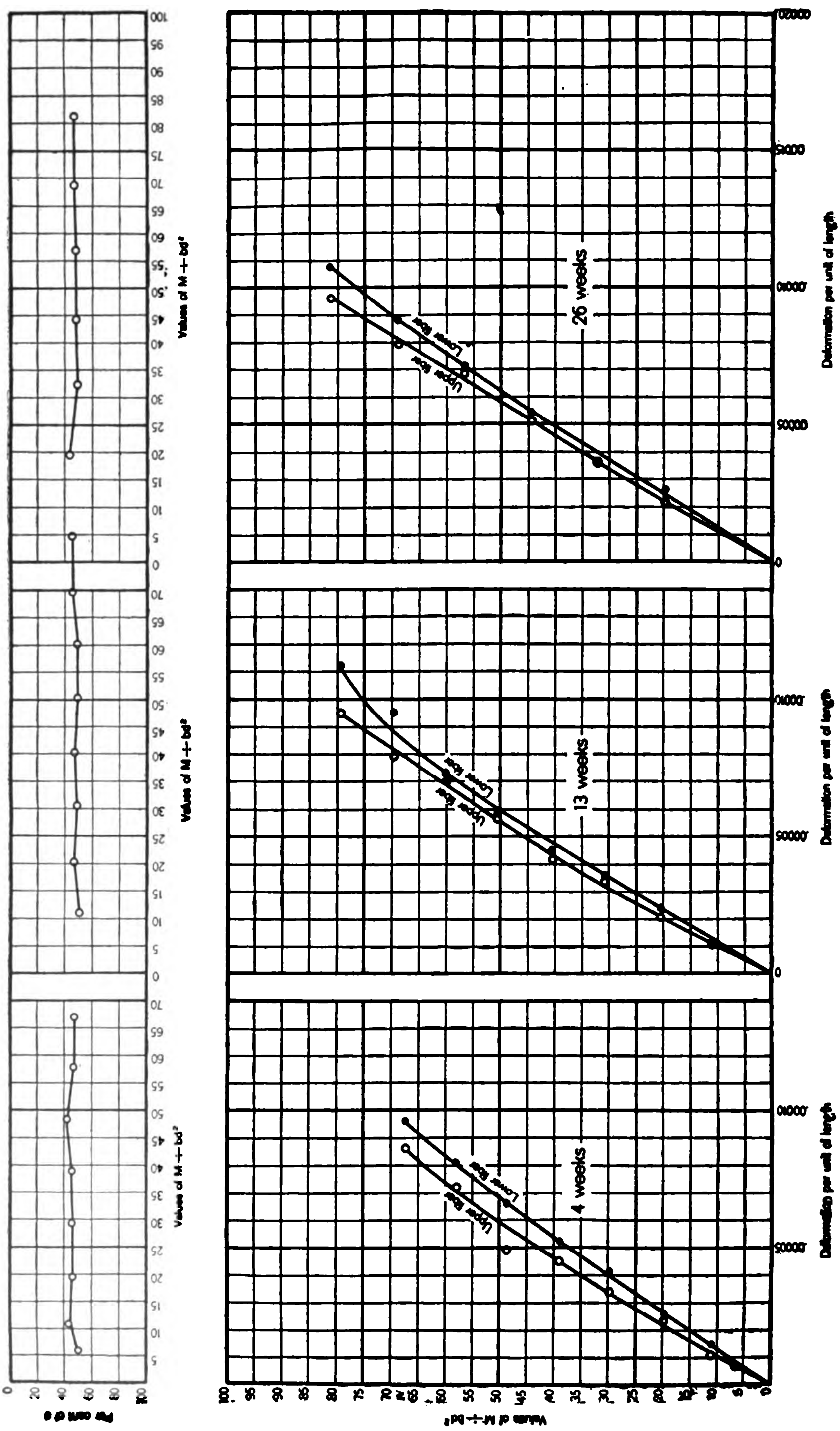


FIG. 12.—Characteristic deformation curves for flexure, gravel concrete of medium consistency; ages 4, 13, and 26 weeks.

per square inch within which the line drawn coincides with the curve is also shown (column 12).

Column 17 gives the ratio of the ultimate strength of the cylinders to that for the cubes.

It is to be regretted that the capacity of the machines composing the equipment was exceeded by the strength of many of the cylinders and cubes at the time these tests were made, preventing the accurate determination of the actual growth of strength with age. There is, however, in almost every case a substantial increase in strength with age.

The effect of consistency on the strength is much more noticeable, and leads to much more uniform results for the cubes and cylinders than for the beams. This would lead one to believe that the effect of consistency is much more noticeable and much more uniform on the compressive strength of concrete than on the tensile strength.

Owing to a breakdown of the engine it became necessary to apply the load by hand for a number of tests. The beams and cylinders, being deemed the most important, were tested in this way, but because of the difficulty of turning the gears of the testing machine by hand the testing of the cubes was omitted.

ILLUSTRATIVE DIAGRAMS.

Figs. 2, 3, 4, and 5 show graphically the effect of age and consistency on the ultimate compressive strength of cinder, granite, gravel, and limestone concretes, as obtained from the tests on the cylinders and cubes and in the modulus of rupture as given by the tests in the beams of constant and variable span.

Figs. 6, 7, 8, and 9 show graphically several characteristic compression-stress deformation curves obtained from tests on the cylinders, while figs. 10, 11, 12, and 13 show the deformation curves for a few of the beams of 12-foot span.

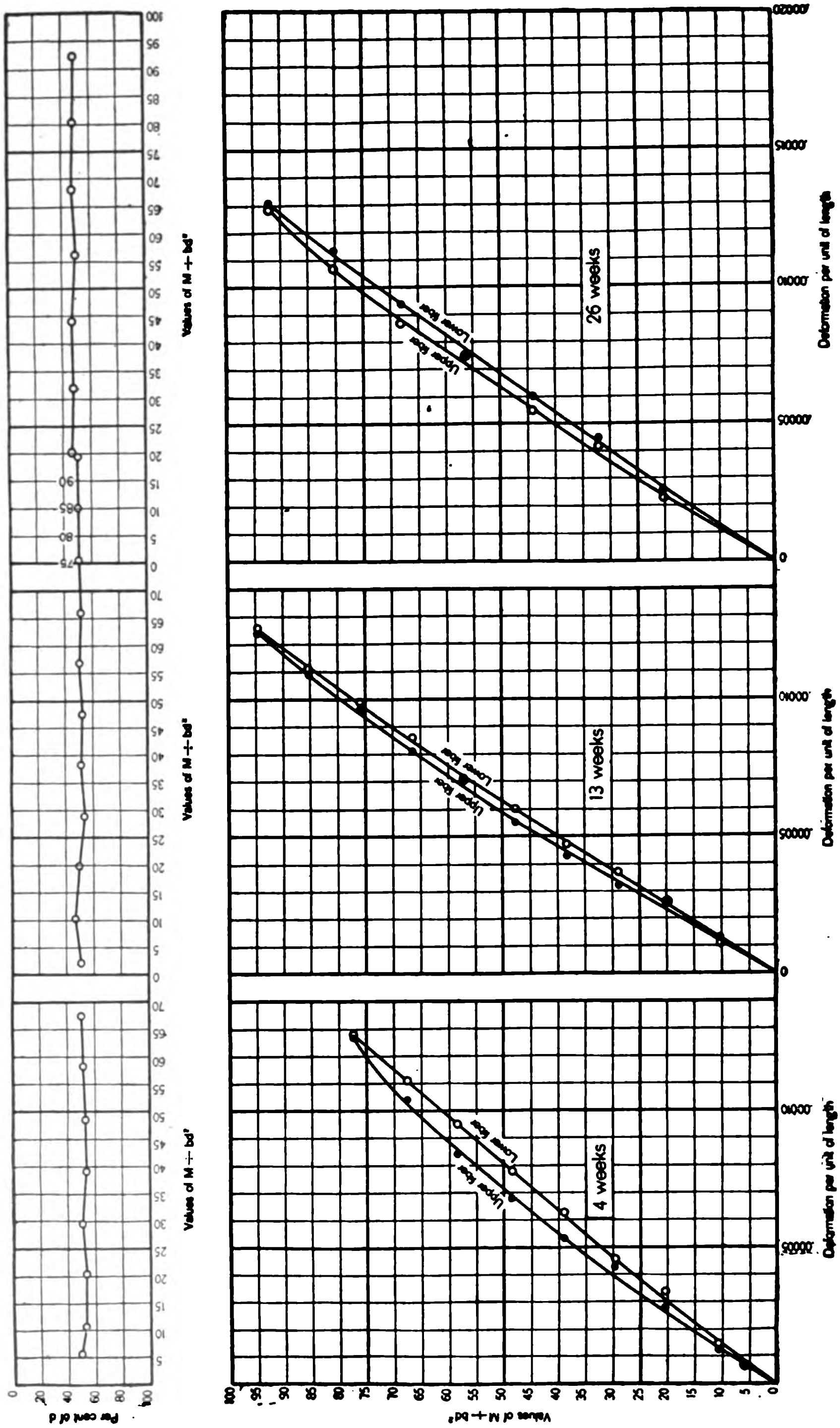


FIG. 13.—Characteristic deformation curves for flexure, limestone concrete of medium consistency; ages 4, 13, and 26 weeks.

SURVEY PUBLICATIONS ON TESTS OF STRUCTURAL MATERIALS.

The following reports, published by the Geological Survey, relate to structural materials, etc.:

BULLETIN 238. Economic geology of the Iola quadrangle, Kansas, by G. I. Adams, Erasmus Haworth, and W. R. Crane. 1904. 8°. 83 pp., 11 pls.

BULLETIN 243.* Cement materials and industry of the United States, by E. C. Eckel. 1905. 8°. 395 pp., 15 pls. 65c.

BULLETIN 260.* The American cement industry, pp. 496–505. 1905. 40c.

BULLETIN 324. The San Francisco earthquake and fire of April 18, 1906, and their effects on structures and structural materials, by G. K. Gilbert, R. L. Humphrey, J. S. Sewell, and Frank Soulé. 1907. 170 pp.

BULLETIN 329. Organization, equipment, and operation of the structural-materials testing laboratories at St. Louis, Mo., by R. L. Humphrey. 1908. 85 pp.

BULLETIN 331. Portland cement mortars and their constituent materials; results of tests made at the structural-materials testing laboratories, St. Louis, Mo., by R. L. Humphrey and William Jordan, jr. 1908. 130 pp.

WATER-SUPPLY PAPER 143. Experiments on steel-concrete pipes on a working scale, by J. H. Quinton. 1905. 8°. 61 pp., 4 pls.

MINERAL RESOURCES U. S. FOR 1901,* 1902, 1903,* 1904, AND 1905.* Cement. A series of annual articles on the cement industry and the production of cement in the United States, by L. L. Kimball. 50c. for each volume.

MINERAL RESOURCES U. S. FOR 1906, pp. 897–905. Advances in cement technology, 1906, by E. C. Eckel.

Reports marked with an asterisk (*) are out of stock, but may be had from the Superintendent of Documents, Washington, D. C., at the prices named. The others will be sent free to anyone interested on application to The Director, United States Geological Survey, Washington, D. C.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 345

MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN 1907

BY ALFRED H. BROOKS AND OTHERS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1908

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INVESTIGATIONS OF MINERAL RESOURCES OF ALASKA IN 1907.

By Alfred H. Brooks and others.

ADMINISTRATIVE REPORT.

By Alfred H. Brooks.

PREFACE.

This volume, as indicated by the title, is a progress report, but this term has a double significance. It is the purpose here to chronicle not only the progress of the investigations of Alaskan mineral resources and to make public the more important economic results, but above all to note the advance of the mining industry throughout the Territory during the year 1907. It is the aim to make these volumes[a] handy works of reference for those who are interested in the mining industry of this northern field. As the preparation and publication of the more elaborate reports and maps, which is the ultimate purpose of the Alaskan work, always requires considerable time, it seems desirable to present the more important economic conclusions in advance. This is especially important in a field like Alaska, where mining advances are taking place so very rapidly. If the information gained by the geologist and engineer is to be of use to the prospector and pioneer miner, it must be given to the public before the explorative stage of mining has passed, even at the risk that some of the conclusions presented in this preliminary way may be set aside when the laboratory investigations are completed.

As in former volumes, the papers here presented fall into three groups—(1) summaries of progress of the various phases of the mining industry in various parts of the Territory during the year, (2) preliminary accounts of investigations in progress or completed, and (3) statements of the results of minor investigations not to be published elsewhere.

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[a] Three similar reports have already been issued: Report on progress of investigations of mineral resources of Alaska, 1904: Bull. U. S. Geol. Survey No. 259, 1905; idem, 1905: Bull. No. 284, 1906; idem, 1906: Bull. No. 314, 1907.

The increasing facilities for transportation and the improvement of the mail service make it possible each year to make these reports more complete as an accurate record of the advancement of the mining industry. As, however, only 20 technical men are engaged in the work, and as they devote a large share of their time to the more elaborate investigations and survey, it is not possible to send a representative of the Geological Survey to each Alaska mining district every year. Therefore the data collected at first hand are supplemented, so far as possible, by information gleaned from various sources, chiefly by correspondence with representative mining men. It is very gratifying to note that there is an increased interest in this phase of the investigation on the part of the mining public, and that much valuable information has been furnished by representative residents of Alaska. Among the many that have assisted in this way are the following, to whom the writer would make special acknowledgment: C. D. Garfield, Wild Goose Mining Company, and Arthur Gibson, of Nome; C. W. Thornton, of Solomon; John A. Dexter, of Golofnin; Falcon Joslyn; Maj. J. P. Clum; R. Wood; P. G. Charles; W. H. Parson, of Fairbanks; S. J. Marsh, of Caro; A. J. Childs, of Deadwood; H. F. Thumm and W. B. Ballon, of Rampart; Frank E. Howard, of Coldfoot; F. J. Wanderwall, of Eagle; F. C. Kelsie, of Kodiak; George M. Esterly, of Nizina; Melvin Dempsey, of Chisna; and the Pioneer Mining Company.

As much the larger part of the value of the annual mineral production comes from the gold placers, the description of placer districts rather dominates other phases of the work in this report. With the increased knowledge of the bed-rock geology gained both through the investigations here to be outlined and through the mining developments, there is a constant accretion of facts bearing on the occurrence of the metalliferous deposits in the bed rock, and in this report, therefore, a more complete statement of this phase of the subject can be presented for southeastern Alaska, the Yukon district, Seward Peninsula, and the Copper River region than has been previously given.

The composite authorship of this volume is evident from the fact that it contains fourteen different papers by eleven different authors. The arrangement of the contributions is, in general, geographic—from south to north—beginning with some papers of a general character. It is unfortunate that the exigencies of prompt publication make it imperative to omit all elaborate illustrations, the reproduction of which necessarily consumes considerable time, and to include only such outline maps and diagrams as can be quickly prepared for printing. The complete reports will contain more detailed illustrative matter.

PROGRESS OF SURVEYS.

INTRODUCTION.

During the season of 1907 twelve parties were engaged in Alaskan surveys and investigations. Of these six were carrying on geologic work, four were making topographic surveys, and two were engaged in stream gaging. The personnel of these parties included 19 technical men and 20 to 25 camp hands. Of the technical men twelve were geologists, four topographers, and three engineers. In addition to these the geologist in charge spent some two months in the field carrying on geologic investigations and visiting field parties. In addition to the field force, four clerks were employed in the office for the whole or a part of the year.

During 1907 topographic reconnaissance surveys were carried over an area of 6,125 square miles. The geologic investigations included reconnaissance surveys of about 4,000 square miles and detailed surveys of about 400 square miles. Much of the time of the geologists was devoted to a study of the mining districts or special problems yielding results which can not be expressed in square miles, and for this reason the area covered by the geologic work is much smaller than that embraced in topographic surveys.

The geographic distribution of the work can be summarized as follows: In southeastern Alaska two parties were at work for a part or the whole of the summer. One was engaged in making detailed surveys of one of the copper and gold mining districts, as well as in general study of the mineral deposits of that section; the other was engaged in making detailed topographic surveys of one of the important mining districts. In the Copper River region one geologic party was devoted to a study of the copper deposits of the Chitina region. In the Yukon placer district one party was engaged in a study of general geologic economic problems. Two parties were employed in the detailed topographic mapping of the mining district adjacent to Fairbanks, and a third was engaged in making a general reconnaissance of the water resources of the same area. In Seward Peninsula one party was engaged in mapping the areal geology of the Solomon and Casadepaga quadrangles; another was engaged in a study of the tin deposits of the western part of the peninsula; a third was engaged in stream-gaging work, supplementing that of the previous season. The following table shows the allotment of the total appropriation of $80,000 to the various districts investigated:

Allotment to Alaskan surveys and investigations, 1907.

Continuation of general investigations of coal resources	$4,700
Surveys and investigations in southeastern Alaska	5,300
Surveys and investigations in Copper River region	12,000
Surveys and investigations in Yukon region	41,000
Surveys and investigations in Seward Peninsula	17,000
	80,000

The appended table summarizes briefly the results of the Alaska work during the ten years which have elapsed since systematic surveys were begun. This table, however, does not show the many detailed investigations which have been carried on in certain mining districts, much of the appropriation having been spent on a class of work that can not be shown in tabular form. It should be noted that practically every district in Alaska that has produced any mineral wealth has been studied, and that many of them have been investigated in considerable detail.

When the reports now in print or in preparation are completed, a statement of the mineral resources of all of southeastern Alaska will have been published, accompanied by geologic maps. Reports on the two most important coal fields—Matanuska and Controller Bay—are in print, containing geologic and topographic maps. The maps of the Matanuska field are on a scale of 4 miles to the inch; those of Controller Bay on a scale of 1 mile to the inch. In the Copper River region the southern copper belt has been investigated and mapped on a scale of 4 miles to the inch, and preliminary statements concerning the northern belt, together with topographic maps, have been issued.

Reconnaissance surveys of the Yukon-Tanana field have been completed and detailed investigations have already been inaugurated. A preliminary report on the entire Seward Peninsula has now been issued, including geologic maps showing the distribution of the gold placers, so far as they have been determined. In addition to this, two of the largest gold-producing districts of this region have been mapped in detail, both geologically and topographically.

The water resources of both Seward Peninsula and the Fairbanks district have been studied, and preliminary reports have been published. In the former district this work will be completed during the coming summer, but the final report on the water available for placer-mining operations in the Yukon-Tanana region must await more extensive surveys.

The investigations above mentioned do not cover all the Survey activities, but a more complete account of the publications will be found at the end of this volume.

Progress of surveys in Alaska, 1898–1907.

Year.	Appropriation.	Areas covered (square miles).					
		Geologic.		Topographic.		Hydrographic.	
		Reconnaissance.	Detailed.	Reconnaissance.	Detailed.	Reconnaissance.	Detailed.
1898	$46,189.60	9,500		14,912			
1899	25,000.00	6,000		8,688			
1900	25,000.00	10,000		11,152			
1901	35,000.00	12,000		15,664			
1902	60,000.00	17,000		20,304	336		
1903	60,000.00	13,000	336	15,008			
1904	60,000.00	6,000		6,480	480		
1905	80,000.00	8,000	550	8,176	948		
1906	80,000.00	9,000	414	10,768	40	1,000	200
1907	80,000.00	4,000	400	6,125	501	1,000	400
	551,189.60	94,500	1,700	117,277	2,305	2,000	600

The above table indicates that, including about 50,000 square miles surveyed by other Government organizations, topographic reconnaissance surveys have been extended over about one-quarter of the Territory of Alaska. Geologic reconnaissance surveys cover about the same amount of territory. The detailed surveys up to the present time are confined to small areas. The rapid mining developments going on in some districts call for detailed surveys, and these will be pushed as fast as means will permit. Besides this, reconnaissance surveys are urgently needed over at least 100,000 square miles additional. Though the hydrographic surveys cover only comparatively few square miles, yet the areas which have been chosen are the most important ones, and it is not likely that the investigations will ever be carried over any considerable percentage of the total area of Alaska.

In planning the work it is aimed to take up the most important investigations first, and therefore much money is spent on the placer districts, which, up to the present time, have yielded by far the larger part of the mineral wealth of the Territory. With the close of the coming field season the investigations of many of the placer districts will be brought to a completion, and this will make it possible to extend the work into other little-known fields and also to give more attention to areas which give promise of becoming centers of lode mining.

GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

GENERAL.

Most of the time of the writer has been given to general administrative duties, in which he has been aided by T. G. Gerdine, who has continued the general supervision of the topographic work. He has also received assistance from E. M. Aten, who was transferred to the division in July, and who has looked after the office routine during the writer's absence in Alaska. The writer was engaged in office work until August, 1907, when he proceeded to southeastern Alaska and spent about ten days with Mr. Wright and Mr. Paige in a study of some of the geologic problems of Kasaan Peninsula. Later he went to Fairbanks, where his time was devoted to familiarizing himself with the more recent mining developments and in visiting the Gerdine, Sargent and Covert parties. The extension of his work into Seward Peninsula, as planned, was prevented owing to delays in travel caused by the low water in the Yukon. After returning to the office, the writer was in part occupied in preparing his statistical report on the gold and silver production in Alaska for 1906, which was published in the Mineral Resources of the United States, 1906. In this work he was assisted by C. W. Wright and A. G. Maddren.

In pursuance of plans outlined about two years ago, W. W. Atwood, assisted by H. M. Eakin, has continued the study of the stratigraphy of the Cretaceous and Tertiary coal-bearing rocks of the Territory for the purpose of establishing correlations and obtaining information in regard to the relative values of the different coal fields. Messrs. Atwood and Eakin began their work in the coal-bearing rocks of southeastern Alaska in May, visiting Admiralty and Kuiu islands. In June they proceeded to the Yukon and spent the balance of the summer in studying the stratigraphy of the coal-bearing rocks. A number of important areas were mapped both topographically and geologically.

Some years ago a systematic study of the methods and costs of placer mining in Alaska was undertaken by C. W. Purington under the auspices of the Geological Survey. The published report[a] found such favor among the mining public that the edition was soon exhausted, and a second edition is in preparation. Mr. J. P. Hutchins, who contributed a valuable section on dredging to this report, has kindly consented to prepare the paper on placer mining and prospecting which forms a part of the present volume. In this paper he discusses some of the important features in the recent evolution in mining methods which has taken place in Alaska. It is fortunate that this phase of the subject of mining, which falls outside of the field of geology, is here treated by one who has had not only the theoretical training, but also long experience in actual mining operations under the peculiar conditions which prevail in this northern region.

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[a] Purington, C. W., The methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905.

SOUTHEASTERN ALASKA.

As reconnaissance work in the important mining districts of southeastern Alaska was completed in 1906, it seemed desirable to devote the funds available for this field in 1907 to the detailed mapping. With this object in view D. C. Witherspoon, assisted by J. W. Bagley, was directed to begin the topographic mapping of Kasaan Peninsula, the most important copper-producing district of southeastern Alaska. Work was begun about the first of May and continued until the first of June, when it was necessary for the party to take up the work in the Yukon district. About 64½ square miles were mapped on a scale of 1 mile to the inch, with 50-foot contours. It is unfortunate that in the short time available for this work it was not possible to complete the mapping of the entire area which should be covered, but plans are under way to accomplish this during the coming field season.

The geologic work in this district was carried on by C. W. Wright, assisted by Sidney Paige, who spent about three months in a detailed examination of the geology and mineral resources of the area. Much attention was given to a close study of the ore deposits as exposed in the rather extensive mining developments of the district. The lack of base maps over the entire area made it impossible to complete the field work, but it is of considerable advantage in the work to be able to revisit some of the localities after the laboratory investigation has been made. A preliminary statement of the results of these investigations is contained elsewhere in this report. (See pp. 98–115.)

At the close of the season Mr. Wright made a hasty trip to the Juneau and other districts, with a view to keeping in touch with the development of the mining industry throughout this part of Alaska. During the last three years he has given special attention to the geology of the ore deposits in southeastern Alaska and the results attained have justified the presentation of a more complete statement of the ore deposits and their relation to the bed-rock geology than has previously been issued. (See pp. 78–97.)

COPPER RIVER REGION.

The first surveys in the Copper River region were made in 1898. This work was continued in 1900, when a geologic reconnaissance of the Chitina Valley was made by F. C. Schrader and A. C. Spencer, and a topographic map of the same area by T. G. Gerdine and D. C. Witherspoon. In 1902 F. C. Schrader and W. C. Mendenhall studied the geology of the northern part of the copper district, while T. G. Gerdine and D. C. Witherspoon executed topographic surveys over the same area. These surveys have been of great value to the mining interests, but in view of the rapid industrial advances in this field it has seemed imperative to supplement them by further investigations of the copper deposits. By so doing the prospector as well as the operator can be furnished with more exact data in regard to the resources and occurrences of mineral deposits, and it also gives opportunity to select the most important areas to be taken up first for detailed investigation.

F. H. Moffit, assisted by A. G. Maddren, was charged with this investigation. The party left Valdez in June and spent the months of July and August and the early part of September in visiting nearly all the prospects of the Kotsina-Chitina copper belt. The latter part of the season was devoted to a study of the geology of the lower part of Copper River. A preliminary account of this investigation is presented in this report (pp. 127–175). The more complete statement is in preparation, and it is hoped that it will be ready for publication about the first of June, and may be issued not later than the first of January, 1909. This later report will contain a topographic map of the lower Copper River region which will be corrected on the basis of the various surveys made in this district for railways and mining developments.

YUKON BASIN.

The systematic surveys begun in the Yukon basin in 1898 have been continued with some interruptions ever since. During 1907 important results were obtained and some large areas were covered by topographic reconnaissance surveys. To L. M. Prindle has fallen the geologic investigations in the general Yukon-Tanana region since 1903. In 1907 Mr. Prindle spent the early part of the season in the study of the geology and mineral resources of the Fortymile region, and reached some important conclusions regarding the distribution and origin of the gold. (See pp. 187–197.) He later visited some of the other mining districts and also studied the section of the Yukon exposed along the Ramparts between Fort Hamlin and the mouth of the Tanana.

Special attention should be here directed to the report which Mr. Prindle has prepared on the distribution and source of the gold in the Yukon-Tanana region. (See pp. 179–186.) His conclusions, though occupying a very few pages, represent the results of extensive field and office studies, and should prove of value to the miner and prospector.

D. C. Witherspoon and J. W. Bagley were charged with the extension of the topographic reconnaissance mapping west of the international boundary and south of the area previously surveyed. They began work the latter part of June near the international boundary south of the Fortymile quadrangle and continued it until about the middle of September, when they went down the

Tanana to Fairbanks by boat. An area of about 6,000 square miles was covered, including practically the entire unmapped belt lying between the Yukon and the Tanana, and extending westward from the boundary as far as the mouth of Delta River. Tanana River from the mouth of the Delta to Fairbanks was also surveyed.

The importance of investigating the water resources in the placer districts having been proved by the work done at Nome in 1907, it was decided to extend similar hydrographic surveys to the Fairbanks district. The funds available for this work were adequate only to prosecute it on a small scale. C. C. Covert reached Fairbanks the latter part of June and spent the balance of the open season in stream measurements in the Fairbanks placer district and in the areas tributary to it. Although the results of one season's investigations can not be considered final in regard to the stream volumes, yet they have value in showing at least the minimum flow for that particular season. Hydrographic data were procured regarding the run-off of about 800 to 1,000 square miles and an area of at least 300 to 400 square miles was surveyed in some detail. Mr. Covert's report is now in print and a brief abstract is presented in another section of this volume. (See pp. 198–205.)

SEWARD PENINSULA.

In view of the complexity of the geology of Seward Peninsula, it is possible to gain an adequate knowledge of the stratigraphic succession only by a large amount of detailed mapping. Such studies alone will furnish information on which to base conclusions regarding the occurrence and distribution of the gold in the bed-rock terranes. During the last two years work of this kind has been carried on in the Nome and Grand Central quadrangles, and in 1907 similar lines of investigation were taken up in the Solomon and Casadepaga areas, where the detailed base maps were also available, by P. S. Smith, assisted by George I. Finlay and F. J. Katz. The entire area of the Solomon quadrangle was completed and the larger part of the Casadepaga also. In addition to this, considerable attention was paid to the economic and mining problems of other mining districts of the peninsula. (See pp. 206–271.)

In accordance with the original plans laid out for investigating the water resources of Seward Peninsula, F. F. Henshaw, assisted by Raymond Richards, was detailed to continue the stream measurements. This work made it possible not only to gain additional information about the streams previously measured, but also to extend this into adjacent areas. Special attention was given to the Kougarok district, and some measurements were also made in other mining districts. A brief statement of the results of this work is given elsewhere in this report (pp. 272–285).

COLLECTION OF STATISTICS.

The Geological Survey is charged by law with the duty of collecting statistics of the mineral production for the entire country. The value of such data has long been fully recognized in the States, where they are depended on by producers, consumers, publishers, and all others who are desirous of obtaining accurate information. Their importance to the various interests of Alaska is incalculable, for it is only on the basis of past production, considered with estimates of the mineral reserves, that the future progress of the mining industry can be forecast.

It is evident that such statistics can have value only provided they are accurate. Though general estimates may have some interest, they can not be relied on as can the accurate statistics which can be made up only from data collected from the individual producers.

The general recognition of these facts by the precious-metal mine operators in the States is attested by the fact that, of the 15,000 to whom schedules are sent, less than 3 per cent fail to reply, and these are, for the most part, the small producers. In Alaska, on the other hand, of the 1,600 placer mine operators to whom the schedules were sent, nearly 60 per cent failed to reply, and among the delinquents were some of the largest companies, who, in all other matters, have shown a great desire to cooperate with the Geological Survey. It is gratifying to record the fact that practically all the Alaska lode-mine operators have shown their interest in the statistical work, for in 1906 all but one furnished the desired information. The same is true of the coal-mine operators and those producing building stone and structural material.

If it were possible to send a representative of the Geological Survey to each one of the gold placer producers, no doubt the information could readily be procured, as then a full explanation of the purposes and the uses to which the figures are put could be made. Unfortunately, however, the conditions of transportation and the funds available for this work do not permit of such procedure. The Survey is, therefore, forced to rely on the courtesy of the individual producer in replying to the schedule sent to him by mail. If the producer does not return the schedule in time to have it included when the statistics are made up, he may, by the amount that he produces (provided there are no other sources of information), reduce the total credited to his district, and thereby nullify the whole purpose of the investigation, which is to obtain accurate figures. That such a procedure has done a grave injustice to Alaska in the past is shown by the fact that in one of the recent years it was discovered that a general estimate published had credited to one of the States $500,000 worth of gold which had been produced in Alaska. Fortunately the mistake was rectified in the publications of the Geological Survey. When accurate returns are obtained from the producers themselves, such a mistake is impossible. It seems probable that this may have happened before, and, unless certain large mining companies modify their practice of refusing information, it will probably happen again and thereby hurt the mining industry of the Territory.

The above criticism applies particularly to the large mining companies and, more especially, to those of Seward Peninsula. This neglect on the part of some of the Nome operators, in the opinion of the writer, is probably due to an oversight rather than to a lack of public spirit, as they have showed a willingness to cooperate with the Geological Survey in other matters. In the Yukon district nearly all the operators to whom blanks were sent have given the desired information, and the writer feels under special obligations to many who have not only returned the schedules promptly, but also furnished lists of other placer-mine operators.

It may be well in this connection to call attention to the fact that the returned schedules are kept under lock and key, and only the few officers of the Geological Survey who make up the totals are allowed access to them. Every precaution is taken to prevent any published figures from giving information, even by inference, of the output of any individual operator. For example, if there are only one or two large producers in a district, the total of that district is not published separately, but is combined with that of another district in the printed report.

The statistics contained in the report for 1907 are based, in part, on estimates, for at this writing not all the schedules have been received from the operators. It is therefore impossible to include the accurate figures in this report. They will, however, be included in next year's volume, just as the accurate statistics of 1906 are included in this report.

It will be the purpose in the future to include, as far as possible, a summary of the mineral production of the Territory in all branches of mining, and it is hoped that before many years the operators will return the schedules so promptly that the correct figures can be given in the annual progress report. If this is not possible, however, they will always find room in the annual report published by the Survey, entitled "Mineral Resources of the United States," and will also appear in the progress report of the following year.

It should be noted that the Survey began collecting statistics from the operators only in 1905, and that previous to that time the statements in regard to production are based entirely on estimates. This holds true of the copper as well as the gold.

PUBLICATIONS ISSUED OR IN PRESS IN 1907.

There have been some unavoidable delays in the publication of some of the reports. This is in part because the stress of other work has prevented authors from completing manuscripts. Another cause of deferred publications is that most of the reports include illustrations whose reproduction, which is done by contract, may require from four to eight months and sometimes even longer. The delay of publications is also due in part to the fact that the funds available for printing have not been adequate for the purpose. For these various reasons the issuing of the reports (now in press) on Seward Peninsula and the Matanuska and Controller Bay regions, has been unavoidably delayed. The publication of the report on the Wrangell and Ketchikan districts has been postponed owing to the fact that the more detailed information gathered in the work of mapping Kasaan Peninsula afforded additional data which it seemed desirable to incorporate, in part at least, in the preliminary report. The following reports were issued during 1907:

REPORTS INCLUDING MAPS.

Administrative report, 1906, by Alfred H. Brooks. Bull. No. 314, pp. 11–19.
The mining industry in 1906, by Alfred H. Brooks. Bull. No. 314, pp. 19–39.
The Alaska coal fields, by G. C. Martin. Bull. No. 314, pp. 40-45.
Lode mining in southeastern Alaska, C. W. Wright. Bull. No. 314, pp. 47-72.
Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. Bull. No. 314, pp. 73-80.
Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. Bull. No. 314, pp. 82-87.
Petroleum at Controller Bay, by G. C. Martin. Bull. No. 314, pp. 89-102.
Reconnaissance in Matanuska and Talkeetna basins, with notes on placers of adjacent region, by Sidney Paige and Adolph Knopf. Bull. No. 314, pp. 104-124.
The Nome region, by Fred H. Moffit. Bull. No. 314, pp. 126-144.
Gold fields of Solomon and Niukluk River basins, by Philip S. Smith. Bull. No. 314, pp. 146-156.
Geology and mineral resources of Iron Creek, by Philip S. Smith. Bull. No. 314, pp. 157-163.
The Kougarok region, by Alfred H. Brooks. Bull. No. 314, pp. 164-179.
Water supply of Nome region, Seward Peninsula, by J. C. Hoyt and F. F. Henshaw. Water Supply Paper No. 196.
The Circle precinct, by Alfred H. Brooks. Bull. No. 314, pp. 205–226.

MAPS PUBLISHED SEPARATELY.

Reconnaissance map of the southern portion of Seward Peninsula.
Reconnaissance map of the northwestern part of Seward Peninsula.
Reconnaissance map of the northeastern part of Seward Peninsula.

These maps are for sale at 25 cents each, or $15 a hundred.

REPORTS AND MAPS IN PRESS.

Geologic reconnaissance of the Matanuska and Talkeetna basins, by Sidney Paige and Adolph Knopf; including geologic and topographic maps. Bull. No. 327.

The gold placers of parts of Seward Peninsula, Alaska, by Arthur J. Collier, Frank L. Hess, Philip S. Smith, and Alfred H. Brooks; including geologic and topographic reconnaissance maps. Bull. No. 328.

Geology and mineral resources of Controller Bay region, by G. C. Martin; including topographic and geologic maps. Bull. No. 335.

The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska, by L. M. Prindle; including topographic reconnaissance maps. Bull. No. 337.

Berners Bay special map. Scale, 1:62,500. Contour interval 50 feet. Topography by R. B. Oliver.

REPORTS IN PREPARATION.

The following papers and maps are in various stages of preparation and will be published as soon as circumstances permit, but probably, for the most part, during the year 1908, provided the funds for printing are sufficient:

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. 2d edition.

Map of Alaska, scale 1:5,000,000, or about 80 miles to the inch, compiled under direction of Alfred H. Brooks.

The geology and mineral resources of the Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright. Bulletin No. 347.

Physiography and glacial geology of the Yakutat Bay region, Alaska, by R. S. Tarr, with a chapter on the bed-rock geology by R. S. Tarr and B. S. Butler.

The Kotsina-Chitina copper region, by F. H. Moffit and A. G. Maddren.

Chitina quadrangle map, scale 1:250,000, by T. G. Gerdine and D. C. Witherspoon.

Controller Bay region special map, scale 1:62,500, by E. G. Hamilton.

Description of the Fortymile quadrangle, Yukon-Tanana region, by L. M. Prindle.

Circle quadrangle map, scale 1:250,000, by D. C. Witherspoon.

Fairbanks quadrangle map, scale 1:250,000, by T. G. Gerdine, D. C. Witherspoon, and R. B. Oliver.

Water-supply investigations in Alaska in 1906–7, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218.

Fairbanks special map, scale 1:62,500, by T. G. Gerdine and R. H. Sargent.

Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit, F. L. Hess, and P. S. Smith.

Geology of the Solomon and Casadepaga quadrangles, by P. S. Smith and F. J. Katz.

The Seward Peninsula tin deposits, by Adolph Knopf.

THE DISTRIBUTION OF MINERAL RESOURCES IN ALASKA.

By Alfred H. Brooks.

INTRODUCTION.

All the published reports on Alaska deal, either directly or indirectly, with the distribution of the mineral resources. Most of these reports, however, treat of special areas or special forms of deposits, and an adequate discussion of the entire subject must await a more complete investigation which shall cover not only all of the Territory, but also all the different types of mineral deposits. In the three previously issued summary reports something of the distribution of the mineral wealth has been indicated on small-scale maps. Last year's report contained a map[a] which showed in a general way the areas of metamorphic rocks known to be the loci of gold deposits. The same maps showed the areas of copper-bearing rocks, together with symbols indicating the localities of gold and copper mines and prospects, thus exhibiting in a general way the distribution of these deposits. On another map[b] of the same report was represented the general distribution of the coal-bearing rocks, as well as the areas underlain by workable coal beds, a special symbol being used to indicate the character of the coal. These two maps were elucidated in the text by brief accounts of the distribution of the economically important deposits. Thus the occurrence of the gold deposits in the metamorphic rocks and their probable genetic relation to the igneous intrusions were pointed out. The description of the coal-bearing rocks included a brief account of their stratigraphy, distribution, and area.

This, then, with some briefer statements published in previous reports,[c] represents the first attempt to deal with the general problem of the distribution and genesis of the mineral deposits of Alaska, the solving of which is the ultimate aim of the investigations here chronicled. Inasmuch as even the preliminary survey of the mineral wealth of Alaska, begun but ten years ago, has been extended over less than a quarter of the Territory, it is needless to state that the data at hand are inadequate to discuss these problems in detail. As, however, it may be of value to the mining interests to present even incomplete matter bearing on the occurrence and distribution of deposits of economic value, it seems best to recur to this subject in the present volume. Fortunately, the occurrence of mineral deposits in the more important mining districts of the Territory—such as southeastern Alaska, the Chitina region, the Yukon-Tanana region, and Seward Peninsula—forms the subject of special papers in this report, and the matter, therefore, need here be only outlined.

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[a] Bull. U. S. Geol. Survey No. 314, 1907, Pl. I.

[b] Op. cit., Pl. II.

[c] See Bull. U. S. Geol. Survey Nos. 259 and 284.

MAP SHOWING MINERAL RESOURCES.

The map of Alaska which accompanies this volume (Pl. I, in pocket) shows graphically the known facts of the distribution of the mineral resources. It is based, for the most part, on observations of members of the Geological Survey, but data from other reliable sources have been used regarding some localities which have not been examined by Survey men.

The distribution of the different kinds of mineral deposits is indicated by symbols, so far as the scale of the map would permit. It has not been possible, however, to make the symbols altogether consistent. The symbol for gold placers is intended to mark the localities where placer gold has been found in commercial quantities, and for the most part it indicates only those places where actual mining has been done. The symbol for auriferous lodes indicates chiefly the operating mines, but includes some prospects which have not yet been productive. The symbol for copper marks the mine localities, as well as some prospects. The symbol for tin deposits indicates chiefly prospects, though some of these have been small producers.

The fact that the geology of coal is much simpler than that of the metalliferous deposits makes it possible to present more facts in regard to its distribution and to present these with a far greater degree of confidence. On the map the occurrence of sediments belonging to the horizons of the coal-bearing rocks is indicated by stippling. These areas can be regarded as the most promising fields for coal prospecting, but should not be taken to indicate the actual distribution of workable coal seams. The areas known to carry coal, probably in workable beds, are marked in black with a letter indicating the quality of the coal.

The location of petroleum seepages is also indicated on the map. All the known seepages occur on the Pacific coast. At Controller Bay there have been two wells which have made a small production of oil.

To make this map complete as regards mineral deposits which have been productive, the localities in southeastern Alaska where there has been an output of gypsum and marble have been marked. These, however, only include the localities of actual production, and the map must not be interpreted as indicating that there are no other occurrences of such deposits in Alaska.

COMMERCIALLY IMPORTANT MINERALS.

The variety of known minerals found in Alaska is too large to permit their being catalogued in this paper, nor would it be possible even to list all those which give promise of becoming of commercial value. It will be the purpose here to briefly set forth a statement of the minerals which thus far either have been produced in commercial quantities or give some promise of soon being added to the commercial products of the Territory.

The output of Alaska includes the metals gold, silver, copper, lead, and tin, and the nonmetallic minerals coal, petroleum, gypsum, and marble. In addition to these, iron, tungsten, antimony, quicksilver, and graphite deposits have been found, which may prove to have commercial importance.

Gold is both the most widely distributed and by far the most important of the minerals yet developed. It occurs in combination with silver and other impurities in the alluvium. The auriferous lodes include both free-milling and concentrating ores. Tellurides have been found, but not in commercial quantities. A few grains of platinum have been found in some of the gold placers, but nowhere in commercial quantities. Silver occurs in association with the gold, both in the lodes and placers. Silver-bearing galena deposits are widely distributed, but have been but little developed.

The developed copper deposits are for the most part sulphides and are chiefly chalcopyrite and bornite. Other copper sulphides, carbonates, and oxides have been found, but these have so far been of less importance. Native copper has been found both in placers and lodes in the Copper and White River basins, but this form of deposit has not been productive up to the present time.

Tin occurs in the form of cassiterite in the York district of the western part of Seward Peninsula and in smaller quantities in other parts of Alaska. In the York region (see p. 251) some stannite has also been found, but the chief tin-bearing mineral is cassiterite. The occurrences are in placers and lodes, both forms of deposits having yielded a small production.

There has been a small output of lead from the galena-bearing ores which have already been mentioned. Antimony occurs as stibnite, and some prospecting is going on for this mineral. Tungsten occurs in scheelite and wolframite, the former having been found in association with the placer gold and the latter in lodes in association with cassiterite. (See p. 263.) Among other metalliferous minerals which have been found in small quantities are bismuth and molybdenum. Mercury occurring as cinnabar has been found both in placers and in veins. None of these minerals is known to occur in commercial quantities.

Magnetite occurs in large bodies on Prince of Wales Island and elsewhere in association with some chalcopyrite deposits. Some of it is reported to be a good Bessemer ore, but no attempts have been made to mine it except for its copper content.

Of the nonmetallic minerals the fuels are of most importance. Peat is the most widely distributed of mineral fuels, but no investigations have been made to determine the commercial value of the deposits.

Lignitic coal is extensively developed in many parts of Alaska and has been mined at a dozen localities. Bituminous and subbituminous coals occur at widely separated localities and have been developed in a small way. Anthracites and semianthracites have thus far been discovered only in the Pacific slope region. The following table, taken from Mr. Martin's report,[a] gives a concise summary of the composition of these coals:

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[a] Martin, G. C., Bull. U. S. Geol. Survey No. 314, 1907, p. 45.

Analyses of Alaska coal.

[Compiled from United States Geological Survey reports.]

	District and kind of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.
	ANTHRACITE.						
1	Bering River, average of 7 analyses	7.88	6.15	78.23	7.74	1.30	12.86
2	Matanuska River, 1 sample	2.55	7.08	84.32	6.05	.57	11.90
	SEMIBITUMINOUS.						
3	Bering River, coking, average of 11 analyses	4.76	13.27	74.84	7.12	1.51	5.68
4	Cape Lisburne, average of 3 analyses	3.66	17.47	75.95	2.92	.96	4.46
5	Matanuska River, coking, average of 16 analyses	2.71	20.23	65.39	11.60	.57	3.23
	BITUMINOUS.						
6	Lower Yukon, average of 11 analyses	4.68	31.14	56.62	7.56	.48	1.90
	SUBBITUMINOUS.						
7	Matanuska River, average of 4 analyses	6.56	35.43	49.44	8.57	.37	1.40
8	Koyukuk River, 1 sample	4.47	34.32	48.26	12.95	--------	1.40
9	Nation River, 1 sample	1.39	40.02	55.55	3.04	2.98	1.39
10	Alaska Peninsula, average of 5 analyses	2.34	38.68	49.75	9.22	1.07	1.30
11	Cape Lisburne, average of 11 analyses	9.35	38.01	47.19	5.45	.35	1.24
12	Anaktuvuk River, 1 sample	6.85	36.39	43.38	13.38	.54	1.20
	LIGNITE.						
13	Port Graham, 1 sample	16.87	37.48	39.12	6.53	.39	1.04
14	Southeastern Alaska, average of 5 samples	1.97	37.84	35.18	24.23	.57	1.02
15	Wainwright Inlet, 1 sample	10.65	42.99	42.94	3.42	.62	1.00
16	Colville River, 1 sample	11.50	30.33	30.27	27.90	.50	1.00
17	Upper Yukon, Canadian, average of 13 analyses	13.08	39.88	39.28	7.72	1.26	.99
18	Upper Yukon, Circle province, average of 3 analyses	10.45	41.81	40.49	7.27	1.30	.97
19	Upper Yukon. Rampart province, average of 6 analyses	11.42	41.15	36.95	10.48	.33	.91
20	Seward Peninsula, 1 sample	24.92	38.15	33.58	3.35	.68	.88
21	Chitistone River, 1 sample	1.65	51.50	40.75	6.10	--------	.79
22	Kachemak Bay, average of 6 analyses	19.85	40.48	30.99	8.68	.35	.77
23	Cantwell River, 1 sample	13.02	48.81	32.40	5.77	.16	.66
24	Kodiak Island, 1 sample	12.31	51.48	33.80	2.41	.17	.66
25	Unga Island, average of 2 analyses	10.92	53.36	28.25	7.47	1.36	.62
26	Tyonek, average of 4 analyses	8.35	54.20	30.92	6.53	.38	.58
27	Chistochina River, 1 sample	15.91	60.35	19.46	4.28	--------	.32

1. Bull. No. 284, p. 74, analyses 1 to 7.
2. Bull. No. 284, p. 98, analysis 1.
3. Bull. No. 284, p. 74, analyses 10 to 20.
4. Bull. No. 278, p. 47, analyses 13 to 15.
5. Bull. No. 284, p. 98, analyses 2 to 17.
6. Bull. No. 218, pp. 62, 63, analyses 26, 28 to 38.
7. Bull. No. 284, p. 98, analyses 18 to 21.
8. Bull. No. 218, p. 62, analysis 28.
9. Bull. No. 218, p. 62, analysis 17.
10. Bull. No. 284, p. 27.
11. Bull. No. 278, p. 47, analyses 1 to 7, 9 to 12.
12. Prof. Paper No. 20, p. 114, analysis 607.
13. Bull. No. 259, p. 170.
14. Bull. No. 284, p. 27.
15. Prof. Paper No. 20, p. 114, analysis 653.
16. Prof. Paper No. 20, p. 114, analysis 620.
17. Bull. No. 218, pp. 61, 62, analyses 3 to 15.
18. Bull. No. 218, p. 62, analyses 16, 18, 19.
19. Bull. No. 218, p. 62, analyses 20 to 25.
20. Bull. No. 247, p. 67.
21. Prof. Paper No. 41, p. 125.
22. Bull. No. 259, p. 170, analyses 3, 4, 7 to 10.
23. Bull. No. 218, p. 62.
24. Bull. No. 259, p. 170.
25. Bull. No. 259, p. 170.
26. Twentieth Ann. Rept., pt. 7, p. 23, analyses 1 to 4.
27. Prof. Paper No. 41, p. 124.

There has been a small production[a] of petroleum from one of the Alaska fields which has been used locally, but the industry is not on a commercial basis. The following extract from a report by Mr. Martin[b] shows the character of the petroleum:

Controller Bay petroleum.—A sample of the petroleum from the well near Katalla has been tested by Penniman & Browne, of Baltimore, with the following results.

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[a] Amount unknown.

[b] Martin, G. C., The petroleum fields of the Pacific coast of Alaska: Bull. U. S. Geol. No. 250, 1905, pp. 57–59.

Test of petroleum from Katalla.

Specific gravity	(0.828 at 15.5° C.) 39.1° B.
Distillation by Engler's method:	
Benzine (80°-150° C.)	21%, 54.9° B. (0.7573)
Burning oil (150°-300° C.)	51%, 40.6° B. (0.8204)
Residuum (paraffin base)	28%, 23.9° B. (0.9096)
Sulphur	Trace.

The burning oil was purified by concentrated sulphuric acid and soda, the volume of acid used up being too small to measure. The purified burning oil was put into a small lamp, where it burned dry without incrusting the wick or corroding the burner, and without any marked diminution of flame. The burning oil compares very favorably in these respects with Pennsylvania oil prepared in the same way.

The following analysis of this petroleum was published by Mr. Oliphant:[a]

Analysis of petroleum from Katalla Bay well.

Specific gravity at 60° F., 0.7958, equal to 45.9° Baumé.

Cold test did not chill at 3° F. below zero.

	Per cent.
Distillation below 150° C., naphtha	38.5
150° to 285° C., illuminating petroleum	31
Above 285° C., lubricating petroleum	21.5
Residue, coke and loss	9
Total	100

The results of the tests may be compared with those of other petroleums in the following table:

Tests of petroleum from Alaska and other fields.

	Alaska.[a]	Alaska.[b]	Pennsylvania.[c]	Ohio.[d]	Colorado.[e]	Mexico.[f]	Beaumont, Tex.[g]
Benzine (80°-150° C.)	21	38.5	16.5	10	16	10	2.5
Burning oil (150°-300° C.)	51	[h]31	54	50	40	60	40
Residuum	28	[h]30.5	29	40	44	30	57.5
Sulphur	Trace.						1.7
Gravity	39.1° B.	45.9° B.			43° B.		22° B.

[a] Penniman & Browne for this report.

[b] Oliphant, F. H., The production of petroleum in 1902: Mineral Resources U. S. for 1902, U. S. Geol. Survey, 1903, p. 583.

[c] Peckham, S. F., Report on Petroleum, p. 365.

[d] Woodman, Durand, Jour. Am. Chem. Soc., vol. 13, p. 168.

[e] Oliphant, F. H., Petroleum: Mineral Resources U. S. for 1901, U. S. Geol. Survey, 1902, p. 580.

[f] Stillman, T. B., Engineering Chemistry, p. 364.

[g] Hayes and Kennedy, Oil fields of Texas-Louisiana coastal plain: Bull. U. S. Geol. Survey No. 212, 1903, pp. 146-151.

[h] See above.

The petroleum is clearly a refining oil of the same general nature as the Pennsylvania petroleum. It resembles the latter in having a high proportion of the more volatile compounds and a paraffin base and in containing almost no sulphur. The proportions of the several constituents given in the table above do not necessarily represent the full amounts that could be obtained in practice by different treatment.

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[a] The production of petroleum in 1902: Mineral Resources U. S. for 1902, U. S. Geol. Survey, 1903, p. 583.

Oil Bay and Cold Bay seepages.—Samples of the seepage petroleum from Oil Bay and Cold Bay have been collected by the writer. They were obtained by skimming the petroleum from the surface of the pools of water, where it was continually rising from the bottom of the pool. An effort was made to obtain as much of the fresher oil as possible. Vegetable and earthy impurities were removed by straining through coarse cloth. Water could not be entirely removed. Oil for lubricating purposes at the neighboring wells is obtained from these pools in this manner.

The fresher oil is dark green. That which has remained on the surface of the pool for some time is dark brown.

The oil has doubtless lost a large part of its volatile constituents. The analyses therefore do not represent the composition which could be expected of the live oil from wells in this region. Such oil would have a lower specific gravity, higher percentage of the more volatile constituents, and lower percentage of the less volatile constituents, residue, and sulphur. It would certainly be better than these samples in all respects, and would resemble them in having a paraffin base. It might not be of so high quality as the Controller Bay petroleum, but nevertheless it would be a refining oil.

The samples were submitted to Penniman & Browne, of Baltimore, who return the following report on their tests:

Tests of samples of seepage petroleum from Oil Bay and Cold Bay.

	Oil Bay.	Cold Bay.
Specific gravity at 60° F	0.9557 (16.5° B.)	0.9547 (16.6° B.)
Distillation by Engler's method:		
Initial boiling point	230° C	225° C.
Burning oil (distillation up to 300° C., under atmospheric pressure)	13.2% (29.5° B.)	13.3% (29.6° B.)
Lubricating oils (spindle oils) (120 mm. pressure, up to 300° C.)	39.2% (22.6° B.)	28.3% (23.8° B.)
Lubricating oils (120 mm. pressure, 300° C. 350° C.)	19.6% (17.9° B.)	18.3% (18° B.)
Paraffin oils (by destructive distillation under atmospheric pressure)	22.4% (20.4° B.)	32.0% (20.4° B.)
Coke and loss	5.6%	8.1%
Total sulphur	0.098%	0.116%

The distillation of the lubricating oils under diminished pressure, corresponding to refinery practice, was carried on until signs of decomposition set in. The resulting residue was unsuitable for making cylinder stock, and was therefore distilled for paraffin oils. These paraffin oils contain a considerable quantity of solid paraffin. It was not practicable to determine the amount of the material with the small amount of oil at our disposal.

The iodine absorption of the oils and distillates has been determined by Hanus's method (solution standing four hours), and is here tabulated:

	Oil Bay.	Cold Bay.
Burning oil	17.8% iodine	17.2% iodine.
Lubricating oil	26.2% iodine	27.2% iodine.
Heavy lubricating oil	35.8% iodine	35.2% iodine.

These iodine numbers upon the lubricating oils were obtained upon the samples. For comparison, samples of similar oils were obtained from the Standard Oil Company, and the iodine numbers determined as follows:

Light distilled lubricating oil (spindle oil)	32% iodine
Dark lubricating oil (engine oil)	45.4% iodine

> The burning oils were tested in a small lamp and found to give a good flame. All the oil was consumed without incrusting the wick or corroding the burner.
>
> The sample of crude oil from Cold Bay was distilled in such a way as to give the maximum yield of burning oil; under these conditions 52.2 per cent of fair quality burning oil was obtained.
>
> The oils are entirely similar; both have paraffin bases, and the products of distillation are "sweet." We are informed that these samples are "seepage oils." If a sufficient yield can be obtained by drilling, a very suitable oil for refinery purposes may be expected, containing a very much larger quantity of the more desirable lighter products.

Of the other nonmetallic deposits, marble and gypsum have been developed and graphite and mica[a] are said to occur in commercial quantities.

Asbestos has been found by Mr. Prindle in the Yukon-Tanana region about 100 miles southeast of Fairbanks and about 20 miles north of Tanana River. A basic dike composed mostly of serpentine cuts the granitic gneisses at this locality and contains small stringers of asbestos up to about 6 inches in width, so far as observed. The dike is several hundred feet wide and apparently of considerable extent. Weathered fibrous masses of the asbestos were found at several places in crossing the dike. There are other dikes of similar character in the same general area, but at no other locality was asbestos observed. The region was only hastily traversed. It is remote and unprospected, and whether asbestos is present in quantities of economic importance has not been determined. It is apparently a favorable area for prospecting for this mineral.

Mention should be made of potable mineral waters which have been exploited in a small way in southeastern Alaska. Hot springs are not uncommon in most of the mining districts, but no investigation has been made of the composition of the waters.

GEOLOGIC OCCURRENCE AND GEOGRAPHIC DISTRIBUTION OF MINERAL DEPOSITS.

In general, it may be said that the Alaska gold deposits are associated with metamorphic rocks, chiefly of lower Paleozoic or pre-Paleozoic age. In several localities auriferous Mesozoic rocks have been found, and there may be some gold deposits which are as late as Tertiary. The copper deposits are in association with Paleozoic (probably chiefly Devonian and Carboniferous) and Mesozoic terranes, with some that may be of Tertiary age. Other metalliferous lode deposits besides those of gold and copper occur in a similar association. In many places there has been found an intimate relation between intrusives (chiefly granitic and especially those of Mesozoic age) and the metal-bearing veins.

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[a] See p. 116 of this bulletin.

The lignitic coals of Alaska occur chiefly in strata which have been correlated under the general name Kenai formation and are probably, for the most part, Eocene in age. Lignitic and subbituminous coals are found in rocks of upper Cretaceous age, and Jurassic terranes (upper) have also been found to carry some low-grade bituminous coals. The high-grade bituminous and anthracite coals occur chiefly in Tertiary rocks, provisionally assigned to the Miocene; but Carboniferous formations (chiefly Mississippian) are known to carry bituminous coals locally. The petroleum seepages of Controller Bay are found in Tertiary rocks, but the source of the oil is probably in strata of older horizons. In the Cook Inlet field the petroleum seepages are from Mesozoic (Jurassic) sediments. Both the marble and the gypsum deposits are of Paleozoic age.

In view of the close association of the gold deposits with the metamorphic rocks and their probable genetic connection with the intrusives, it becomes important to consider the distribution of these two kinds of rocks. This matter was discussed at some length in the Progress Report of last year.[a] It was there shown that there are three fairly well defined belts of metamorphic rocks in Alaska, and to these should now be added some smaller outlying zones of the main belts. One, skirting the Pacific seaboard, stretches through southeastern Alaska, probably occurs in the St. Elias Range, and has been recognized on lower Copper River, in Kenai Peninsula, and on Kodiak Island. The St. Elias Range has not been traversed, but the presence of metamorphic rocks is inferred from what is known of the geology along both margins, and that they are mineralized is indicated by the fact that the alluvium derived from them is locally auriferous. This zone of metamorphic rocks is known to include rocks belonging to the Paleozoic, from the Silurian to the Carboniferous; it may include older sediments, and, as defined, probably embraces some Mesozoic beds.

In southeastern Alaska the metamorphic rocks, chiefly of Paleozoic age, are bounded on the east by the great granitic batholiths of the Coast Range, and stocks of similar rocks are abundant in the coastal fringe of islands. Granitic and granodioritic intrusives are also known to occur in the St. Elias Range. In the Prince William Sound and Kenai Peninsula region intrusives are also present, but apparently are not so common as in the eastern and southern parts of the belt. An extension of the Coast Range intrusives has also been traced along the eastern margin of the St. Elias Range, through Canadian territory, and into the Nutzotin Mountains, which form the easterly extension of the Alaska Range. This zone is represented by isolated stocks, marking one general axis. It is probably safe to conclude that the intrusive masses of the Alaska Range are of the same age. If this is true, the granites reported in the Iliamna and Lake Clark region probably belong to the same period of igneous activity.

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[a] Bull. U. S. Geol. Survey No. 314, 1907, pp. 22–26.

In another section of this report (pp. 81–85) Mr. Wright points out the close association and genetic relation of the ore bodies and the granitic intrusives in southeastern Alaska. This holds both for the copper and gold deposits. The good exposures and accessibility of this region and the relatively large amount of prospecting and mining done have made it possible to trace out certain zones of mineralization which are the loci of the commercial ore bodies. Less work has been done by both the prospector and the geologist in the Prince William Sound region, so that the geographic distribution and the genetic relations of the ore bodies are still obscure; and in Kenai Peninsula the problems connected with the bed-rock source of the placer gold are practically entirely unsolved.

On tracing the eastern line of intrusion it is found that the Rainy Hollow copper district and the Kluane copper and gold deposits, both in Canada, probably bear a relation to the granitic rocks similar to that shown by those of southeastern Alaska. To pass still farther westward, what is known of the geology of the Chistochina placer district[a] and inferred of the Valdez Creek placers suggests a causal relation between the intrusives and the bed-rock source of the gold. Similar conditions may hold in the Alaska Range, where the same types of rocks are found in association, and gold has been found on both margins of the mountains, namely, in the Bonnifield and Kantishna districts on the north and in the Yentna district on the south.

This belt of altered sediments along the Pacific coast, with its northern arm skirting the upper part of the Copper River basin and extending into the Alaska Range, is, then, a locus of mineral deposits which, in part at least, bear a genetic relation to the intrusives. The facts presented show that the mineralization is widespread, but it is not intended to imply that the entire belt carries workable ore bodies. In fact, the studies of Mr. Wright in southeastern Alaska clearly show that the mineralization there follows certain zones lying within the metamorphic belt and that the position of these zones is determined by the intrusive mass.

The two zones of copper-bearing rocks which lie north and south of the Wrangell Mountains belong to this same general province, but the type of mineralization appears to be different from those above described. As Mr. Moffit (see p. 135) points out, the southern or Kotsina-Chitina belt lies at the contact of a greenstone and an overlying Mesozoic limestone, and the same probably holds true of the northern or White-Nabesna belt. It is probable that in the northern area some of the Tertiary lavas are also copper bearing. It will require much more field investigation to determine the geologic relation of these inland copper districts than to reach similar results for the coastal zone.

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[a] Mendenhall, W. C., The geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41, 1906.

A second belt of metamorphic rock, locally auriferous, lies inland, stretching through the Yukon-Tanana region from the international boundary, and may be extended to the southwest toward the Bering Sea. The recently discovered auriferous gravels on the lower Yukon and in the Innoko region (see pp. 47–49) may lie in a southwesterly extension of this belt of metamorphic rocks. The sediments of this zone are of various ages, but schists of pre-Ordovician age and Devonian limestones, greenstones, and slates predominate, though Silurian, Carboniferous, and Mesozoic rocks are also present. (See p. 180.) Granite and other intrusives are not uncommon.

Within this belt there are a number of important placer fields; in fact, from a scientific standpoint, all of the alluvium included in it is more or less auriferous. Mr. Prindle describes this field in another part of the report (see p. 184) and suggests a possible genetic relation between the intrusives and the source of the metals. It is of interest to note that some of the Mesozoic slates included in this zone are mineralized and that the intrusives are in part of Mesozoic age, all of which suggests an analogy to the deposits of the coastal belt, though much more work will have to be done before the geologic relation of the two can be established.

A third belt of metamorphic rocks lies north of the Yukon and south of the Endicott Mountains, which separate the basin of that river from the Arctic slope. These rocks stretch westward and, traversing the Kobuk Valley, are probably continued in the altered Silurian and older sediments which make up the larger part of Seward Peninsula. Within this belt placer gold has been found in the Koyukuk, Chandalar, and Kobuk valleys and over much of Seward Peninsula. The occurrences of metalliferous lodes in Seward Peninsula are discussed elsewhere in this volume by Mr. Smith and Mr. Knopf (pp. 206–271). The age of the mineralization in this region is unknown, but it seems possible, at least, that it belongs to the same period as that of the Yukon.

Although the gold and copper deposits thus far developed lie for the most part in the zones of metamorphic rocks (chiefly of Paleozoic age) above described, yet there are some other types of ore bodies which seem to fall into a different category. The occurrence of copper in the Tertiary lavas of the White-Nabesna belt has been already referred to. In Alaska Peninsula and the adjacent islands some auriferous lodes have been found in lavas which may be Tertiary and are certainly no older than the Mesozoic. One deposit of this kind, the Apollo mine on Unga Island, has been a large producer, and some recent lode discoveries in Alaska Peninsula appear to give promise of being of commercial importance. An auriferous quartz vein has also been found on Unalaska Island, but has not proved to be extensive enough for profitable exploitation. It is worthy of note that stocks of granitic rocks are reported in this province, and it is not impossible that here, too, the ore bodies may have a genetic relation to the intrusives.

As the coal resources of Alaska were discussed at some length by Mr. Martin in last year's report,[a] it will not be necessary to do more than briefly outline the subject here. The map (Pl. I, in pocket) shows that coal-bearing rocks are widely distributed, but that there is no one field which is comparable in size to many of those in the States. Mr. Martin has computed the entire area of the known Alaskan coal fields to be 12,644 square miles, which is about the same as that of the bituminous field of Pennsylvania. Two facts should be borne in mind in connection with these figures: (1) In more than half of this area the coal is lignitic and (2) there is a strong probability that large coal fields exist in the unexplored portions of northern Alaska. Of the 12,644 square miles of coal-bearing rocks only about 10 per cent are known to carry workable coal seams, the balance being practically unprospected. The Controller Bay and Matanuska fields, aggregating about 100 square miles of land underlain by workable coals, are the only areas containing fuels of the highest grade which have thus far been found in the Territory. The Cape Lisburne fields, however, carry a fairly good grade of bituminous coal, and it may be found to extend much farther eastward than is indicated on the accompanying map.

The known petroleum-bearing areas are confined to the Pacific coast regions of Alaska. One is at Controller Bay, with an eastern extension at Yaktag; the other lies along the margin of Alaska Peninsula. At both these localities there are strong seepages, and at Controller Bay two wells have been drilled which have made a small production.

The marble thus far developed occurs in the Paleozoic rocks of southeastern Alaska. Quarries have been opened at three localities, and there is a probability of marble being found at other places in this part of the Territory. Gypsum deposits have been found in the Carboniferous rocks of Chichagof Island, but are not known elsewhere in the Territory. Granite is widely distributed, and in the coastal belt of the Territory may have a future value as a building stone.

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[a] Bull. U. S. Geol. Survey No. 314, 1907, pp. 40–46.

THE MINING INDUSTRY IN 1907.

By Alfred H. Brooks.

INTRODUCTION.

The year 1907 witnessed a marked advancement in the mining industry as a whole throughout Alaska, though the statistics show a falling off in both the gold and the copper production. The former is due to certain labor difficulties at Nome and Fairbanks, and the latter to the general depression in the copper-mining industry prevalent throughout the country. Had it not been for these setbacks, the mineral output of Alaska for 1907 would have exceeded that of 1906. Considering the conditions, the production, as shown in the following table, is large.

Mineral production in Alaska, 1906–7.

	1906.		1907.		Increase (+) or decrease (−).	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold .... ounces..	1,066,033	$22,036,794	[a]966,146	$19,600,000	− 99,884	−$2,436,794
Silver .... do....	203,500	136,345	[a]186,271	111,963	− 16,229	− 24,382
Copper .... pounds..	5,871,811	1,133,260	[a]5,200,000	1,040,000	−671,811	− 93,260
Tin		38,640		[a]20,000		− 18,640
Coal .... short tons..	5,541	17,974	5,150	27,850	− 391	+ 9,876
Marble and gypsum....		11,995		71,958		+ 59,963
		23,375,008		20,871,771		− 2,503,237

[a] Preliminary estimates.

Though the year 1907 shows a falling off of two and a half million dollars in the value of the mineral production as compared with 1906, yet it must be remembered that much of the advancement in the mining industry can not be expressed in terms of statistics of production. This is especially the case in a new land like Alaska, where a very great amount of unproductive preliminary work must be done before large mining plants can be installed. The following table shows the total value of the mineral production since the first placers were opened up in 1880. The value of the mineral output in 1880 is estimated at $20,000; that of 1907 at over $20,000,000, or nearly three times the purchase price of the Territory.

Value of total mineral production of Alaska, 1880–1907.

By years.				By substances.	
1880-1890	$1,686,714	1900	$8,238,294	Gold	$123,185,494
1891	916,920	1901	7,007,398	Silver (commercial value)	1,059,468
1892	1,096,000	1902	8,400,693	Copper	3,436,779
1893	1,053,570	1903	8,941,614	Tin	92,640
1894	1,305,257	1904	9,567,535	Coal	270,329
1895	2,386,722	1905	16,477,742	Marble and gypsum	87,507
1896	2,980,087	1906	23,375,008		
1897	2,538,241	1907	20,837,861		128,132,217
1898	2,585,575				
1899	5,703,076		128,098,307		

In 1907 notable advances were made in the development of the copper mines of the Ketchikan district and in certain features of gold mining in the Juneau district. To the west there has been great activity in the construction of railways to reach the Controller Bay coal fields and the Kotsina-Chitina copper district. On Prince William Sound there has been much prospecting, and several of the mines have made shipments. There has also been considerable prospecting on gold and copper lodes in Kenai and Alaska peninsulas. Mining has continued in the Yentna district, which still appears to be a field of small operators. Systematic prospecting has been continued in the Matanuska coal field, and considerable work has been done on the Alaska Central Railway from Seward, the completion of which will render both the Matanuska and the Yentna districts more accessible.

In the Yukon basin great activity has been shown in the Fairbanks district, where the railroad has been extended and a number of new creeks have been opened up. In the Fortymile region several dredges have been installed, and several ditches have been built in the Circle and Rampart districts. The only verified discoveries of the year were the Innoko and Chandalar placer fields. In the latter part of 1907, however, an important discovery of placer gold was reported from the Koyuk district, but at this writing the news remains unverified. In Seward Peninsula the advancements have been along the lines of developing placer deposits already prospected, but there has also been considerable prospecting for lode deposits.

TRANSPORTATION.

The high cost of transportation is still the most serious problem which confronts the Alaskan miner. Although the conditions in southeastern Alaska and other portions of the Pacific seaboard leave little to be desired, and the water rates to Nome are comparatively low, yet, when the coastal region is left behind, all mining operations have to pay a heavy tax to transportation. This affects not only the material and supplies used in mining, but also the labor. As in most Alaska placer camps there is a much larger demand for labor in summer than in winter, the annual influx of a large number of miners in summer should be encouraged. Unfortunately, the cost of transportation to many of the interior camps has, up to the present time, been so high as to discourage laboring men from going into the interior for the short summer season, in spite of the high wages which are paid. A movement is now on foot in Fairbanks to rectify these conditions somewhat, but the problem can never be adequately solved until the Yukon districts are connected with the Gulf of Alaska by a railway.

In Seward Peninsula there has been no railway construction additional to what was reported last year. At Fairbanks, however, about 20 miles of railway were added to the Tanana Valley system and practically all the creeks are now connected by railway with water transportation on the Tanana.

The Alaska Central Railway continued construction during the year 1907, but owing, it is said, to financial conditions, not many miles of track were laid down. The railway still lacks nearly 100 miles of reaching the Matanuska coal fields. The railway situation at Copper River is treated by Mr. Moffit in another part of this report. It appears that in this part of Alaska there has been a lack of a systematic plan in the choice of a coast terminal or of a route inland, and this fact, together with rivalry between conflicting interests, has seriously retarded construction.

Some of the most important work that the Federal Government is doing in Alaska to further commercial advancement is the construction of wagon roads, carried on under the direction of Maj. W. P. Richardson. In his report for 1907[a] Major Richardson states that about 90 miles of wagon road, 251 miles of sled road, and 118 miles of trail were constructed during the year. This makes the total to date 165 miles of wagon road, 242 miles of trail, and 384 miles of sled road.

METAL MINING.

INTRODUCTION.

Though the statistics of production show a decided decrease in the output of metals in 1907 as compared with 1906, yet the industry as a whole showed a healthy growth. As in previous years, by far the greater part of the value of the output was in the gold, most of which came from placers. It is estimated that the value of placer-gold production in 1907 was $16,400,000, as compared with a production of $3,200,000 from the lode mines. The following table[b] presents a summary of the metal production since mining began in 1880:

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[a] Ann. Rept. War Dept., fiscal year ended June 30, 1907.

[b] A statement of the method of collecting statistics will be found on p. 14.

Production of gold, silver, and copper in Alaska, 1880–1907.

Year.	Gold.		Silver.		Copper.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.	Quantity (pounds).	Value.
1880	968	$20,000	10,320	$11,146	3,933	$826
1881	1,935	40,000			----------	----------
1882	7,256	150,000			----------	----------
1883	14,566	301,000			----------	----------
1884	9,728	201,000			----------	----------
1885	14,513	300,000			----------	----------
1886	21,575	446,000			----------	----------
1887	32,653	675,000			----------	----------
1888	41,119	850,000	2,320	2,181	----------	----------
1889	43,538	900,000	8,000	7,490	----------	----------
1890	36,862	762,000	7,500	6,071	----------	----------
1891	43,538	900,000	8,000	7,920	----------	----------
1892	52,245	1,080,000	8,000	7,000	----------	----------
1893	50,213	1,038,000	8,400	6,570	----------	----------
1894	61,927	1,282,000	22,261	14,257	----------	----------
1895	112,642	2,328,500	67,200	44,222	----------	----------
1896	138,401	2,861,000	145,300	99,087	----------	----------
1897	118,011	2,439,500	116,400	70,741	----------	----------
1898	121,760	2,517,000	92,400	54,575	----------	----------
1899	270,997	5,602,000	140,100	84,276	----------	----------
1900	395,030	8,166,000	73,300	45,494	250,000	40,000
1901	335,369	6,932,700	47,900	28,598		
1902	400,709	8,283,400	92,000	48,590	360,000	41,400
1903	420,069	8,683,600	143,600	77,843	1,200,000	156,000
1904	443,115	9,160,000	198,700	114,934	2,043,586	275,676
1905	536,101	15,630,000	132,174	80,165	4,805,236	749,617
1906	1,066,030	22,036,794	203,500	136,345	5,871,811	1,133,260
1907	966,146	19,600,000	186,271	111,963	5,200,000	1,040,000
	5,739,026	123,185,494	1,713,646	1,059,468	19,734,566	3,436,779

NOTE.—Gold and silver production for 1880–1904 based on estimates of the Director of the Mint; for 1907, preliminary estimate. Silver values are average commercial values for year and not coinage value. Copper production for 1880 from Tenth Census (vol. 15, p. 800); for 1900–1904, estimated; for 1907, preliminary estimate. Copper values are based on averages for year.

In the absence of detailed information regarding the source of the metal production for 1907, it may be of interest to consider that of 1906, as shown in the following table:

Source of gold, silver, and copper in Alaska in 1906, by kinds of ore.

Ores.	Gold.		Silver.		Copper.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.	Quantity (pounds).	Value.
Siliceous ores	162,005.12	$3,348,943	23,529	$15,765	----------	----------
Copper ores	3,911.17	80,851	27,861	18,666	5,871,811	$1,133,260
Placers	900,113.62	18,607,000	114,678	76,835	----------	----------
	1,066,029.91	22,036,794	[a] 166,068	111,266	5,871,811	1,133,260

[a] This amount of silver is from mine returns. In other tables the silver production shown is from figures arrived at by agreement with the Director of the Mint.

In the following table the total gold production is distributed according to districts, so far as the information at hand will permit. The error in distribution is believed to be less than 10 per cent, and it is hoped in the future to eliminate it altogether. (See p. 14.) The production from the Pacific coast belt is, for the most part, from the lode mines of southeastern Alaska, for the placers from this region now yield less than $100,000 annually. The gold credited to the Cook Inlet and Copper River region is all from placers and includes the production of the Nizina, Chistochina, Sunrise, and Yentna districts. The gold output from Seward Peninsula and the Yukon basin[a] is nearly all from placers, there being only one lode mine on a productive basis.

Value of gold production of Alaska, with approximate distribution, 1880–1907.

Year.	Pacific coastal belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula.	Total.
1880	$20,000				$20,000
1881	40,000				40,000
1882	150,000				150,000
1883	300,000		$1,000		301,000
1884	200,000		1,000		201,000
1885	275,000		25,000		300,000
1886	416,000		30,000		446,000
1887	645,000		30,000		675,000
1888	815,000		35,000		850,000
1889	860,000		40,000		900,000
1890	712,000		50,000		762,000
1891	800,000		100,000		900,000
1892	970,000		110,000		1,080,000
1893	833,000		200,000		1,038,000
1994	882,000		400,000		1,282,000
1895	1,569,500	$50,000	709,000		2,328,500
1896	1,941,000	120,000	800,000		2,861,000
1897	1,799,500	175,000	450,000	$15,000	2,439,500
1898	1,892,000	150,000	400,000	75,000	2,517,000
1899	2,152,000	150,000	500,000	2,800,000	5,602,000
1900	2,606,000	160,000	650,000	4,750,000	8,166,000
1901	2,072,000	180,000	550,000	4,130,700	6,932,700
1902	2,546,600	375,000	800,000	4,561,800	8,283,400
1903	2,843,000	375,000	1,000,000	4,465,600	8,683,600
1904	3,195,800	500,000	1,300,000	4,164,600	9,160,000
1905	3,430,000	500,000	6,900,000	4,800,000	15,630,000
1906	3,454,794	332,000	10,750,000	7,500,000	22,036,794
1907	3,100,000	200,000	9,300,000	7,000,000	[a]19,600,000
	40,520,194	3,267,000	35,081,000	44,262,700	123,185,494

[a]Preliminary estimate.

COPPER AND GOLD LODES.

The productive lode deposits include those of gold, silver, copper, and tin. During 1907 some small shipments of antimony ore were made. In 1907 there were twelve gold and silver mines on a productive basis, as compared with thirteen gold and silver mines in 1906. Fifteen copper mines made some shipments of ore in 1907, as compared with fourteen in 1906. It should be added, however, that the depression in the copper-mining industry led to the closing down of most of the copper mines in August and September, 1907. There was, however, a marked activity in prospecting for copper lodes in various districts. The statistics of tonnage and values for 1907 not having been made up, it seems best to make the following quotation in relation to the production of 1906:[b]

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[a] This refers, of course, only to the Alaskan Yukon basin, and does not include the production of the Klondike and other Canadian camps.

[b] Mineral Resources U. S. for 1906, U. S. Geol. Survey, 1907, p. 137.

The tonnage of all the lode mines of Alaska in 1906 was 1,510,185 short tons, an increase of 87,670 tons over 1905. Of siliceous ores 1,404,456 tons were mined, of which 1,353,286 tons must be credited to the Treadwell group of mines on Douglas Island, near Juneau, leaving only 51,170 tons as the product of the other gold-quartz mines. The average gold and silver extraction from all siliceous ores was $2.40 per ton. For the 51,170 tons of the siliceous ores other than those from the Treadwell group, it was $4.58 per ton. A total of 105,729 tons of copper ores yielded an average of $0.94 per ton of gold and silver, and copper to the amount of 2.77 per cent. The copper percentage in Prince William Sound was estimated at 3.69. It may be noted from the tables that the content of silver in siliceous ores is less than 1 per cent of the value of the ore.

The production of tin in Alaska since it was first mined in 1902 is shown in the following table. Most of this production is from placer mines, of which two were in operation in 1907.

Value of production of tin in Alaska, 1902–1907.

1902	[a] $8,000
1903	[a] 14,000
1904	[a] 8,000
1905	[a] 4,000
1906	38,640
1907	[b] 20,000
	92,640

The advances made in the productive lode-mining districts are fully set forth in the local reports included in this volume. As in the previous year, the most notable advances in lode mining were the developments in the copper deposits of the Ketchikan district and in the auriferous deposits of the Juneau district. Prince William Sound also was the scene of much mining activity. As yet these are the only fields of extensive lode mining. The total value in 1907 of the metal production from the mines of southeastern Alaska is estimated at $4,100,000; that from Prince William Sound less than $200,000.

Mr. Moffit shows (see pp. 127–178) that much attention was paid to the copper deposits of the Kotsina-Chitina belt. Current reports indicate that about 300 men were engaged during the summer months in prospecting the northern copper field, extending from White River westward to the Nabesna, a westerly fork of the Tanana. The inaccessibility of the region has made it difficult to procure supplies and material necessary for systematic prospecting. In this field both sulphide and native copper deposits have been found. During the last year, however, considerable stripping and some open-cut work was done.

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[a] Estimated.

[b] The value for 1907 is in part based on statements from the producers, but the full returns are not obtainable at the date of the publication of this report.

In the region lying adjacent to Cook Inlet and extending to the south and north, including the Susitna basin, Iliamna Lake, and Alaska Peninsula, considerable lode prospecting has been going on during the last two years. This region has, however, not recently been visited by any representative of the Geological Survey, and the information regarding the lode deposits is very inadequate. Current reports indicate that copper-bearing and auriferous lodes have been discovered in Kenai Peninsula and that they are being carefully prospected. The copper-bearing lode in the Iliamna Lake region, according to current report, is still being investigated.

There is also a reported occurrence of auriferous lodes in the Alaska Peninsula region. Up to the present time the only lode deposit which has been developed in this province is the Apollo mine, on Unga Island, which for a number of years was a very large producer. Current reports indicate that there may be similar deposits in other parts of this region, and specimens sent to the office of the Geological Survey show that auriferous quartz does occur in this field.

Among the other districts in which lode prospecting is said to be yielding favorable results are the Susitna basin and the Kuskokwim basin. Definite information regarding these occurrences, however, is not at hand.

In the Yukon-Tanana region, as shown by Mr. Prindle (see p. 184), practically no lode mining has been attempted, though for the last two years considerable attention has been given to prospecting certain auriferous veins. Noteworthy is the reported discovery of a cassiterite-bearing lode in the Circle district.

In Seward Peninsula Mr. Smith (pp. 206–208) indicates that there was great activity in prospecting during 1907, though up to the present time only one lode mine has reached a producing state. As Mr. Knopf shows (pp. 251–267), there was considerable prospecting in the York tin region. Of considerable interest in this area is the discovery of wolframite-bearing lodes, which may have a value for their tungsten content. The prospecting for antimony in Seward Peninsula has continued, as shown by Mr. Smith (pp. 244–245), and there was a small production of stibnite.

PLACER DISTRICTS.

INTRODUCTION.

The placer mines of Alaska still lead all other forms of mining in the value of the output. In 1907 the placer mines produced about $16,400,000 worth of gold, compared with a production valued at $18,607,000 in 1906. This decrease in value of $2,357,000 can be charged to the labor difficulties at Fairbanks and Nome. Nearly half the placer-gold production in 1907 came from the Fairbanks district, and Seward Peninsula stands second in output, with a production valued at about $7,000,000. It is estimated that the silver recovered from placer gold in 1907 had a value of about $60,000.

The discovery of two new placer districts, the Chandalar and the Innoko, where small productions were made, was reported during the year.

The important feature of the placer-mining industry in 1907 was the general unsettled condition of labor in two of the most important fields, namely, Seward Peninsula and Fairbanks, which led to a notable falling off in production. Of significance is the installation of three dredges in the Fortymile district. Important developments were also made in the Glenn Creek region of the Rampart district.

PACIFIC COAST REGION.

The region tributary to the Pacific coast is of relatively small importance as a producer of placer gold, but includes a number of separate districts. These, named from south to north, are the Juneau and Porcupine districts in southeastern Alaska; the beach placers of Lituya Bay and Yaktag; the Nizina and Chistochina districts of Copper River; the Cook Inlet placer field; and the beach placers of Kodiak and adjacent islands. In 1907 the total production of all these placer districts amounted probably to less than $300,000.

There was but little placer mining in southeastern Alaska. A noteworthy attempt was made by a company to develop the placers on Porcupine Creek in a systematic way. Considerable money was spent in building a flume and preparations were made to mine the alluvial deposits on a large scale. Beach mining continued at several places along the Pacific coast, but the total output probably did not exceed $25,000. The most important locality is Yaktag, but some mining was done also on Kodiak and the adjacent islands.

In the Copper River region a large hydraulic plant was installed in the Nizina district, several other properties were operated, and preparations were made for further installation of mining plants on Dan Creek. Considerable work was also done in the Chistochina district during the summer of 1907, though the gold output was smaller than it has been in past years. The long distance to supplies and the consequent high cost of mining have made it impossible to develop any but the richest ground in this camp.

An important event was the discovery of rich placer ground on the benches of Valdez Creek, a tributary of the upper Susitna, about 200 miles inland from Valdez. Valdez Creek has been a small producer for a number of years, and last summer the discovery of some rich ground was reported. Some very coarse gold was found, a $1,000 nugget being reported. Of the extent of these deposits, however, nothing very definite has been learned by the writer.

In the Cook Inlet field the old Sunrise district (Kenai Peninsula) has been a small producer, as have also some of the streams north of Turnagain Arm. Of more importance in this general field is the development of the Yentna diggings, which lie about a hundred miles from tide water. The ground is said to be shallow and sufficiently rich to pay for operation on a small scale. The largest producers are reported to be Poormans, Nugget, Falls, and Peters creeks, but a number of other streams carry gold. The exact production is not known, but it appears to have exceeded that of the Sunrise district.

SEWARD PENINSULA.

The value of the output of gold in Seward Peninsula for 1907 is estimated to have been about $500,000 less than it was in 1906. This decrease is to be charged chiefly to the labor conditions. The Nome precinct continued to be the first in order of production, with an output of more than 50 per cent of the total $7,000,000 credited to the peninsula. The Council and Fairhaven precincts probably stand second, having an output about equal in value. Mining on Seward Peninsula is fully described by Mr. Smith (pp. 206–250) elsewhere in this report.

YUKON BASIN.

INTRODUCTION.

The preliminary estimates for 1907 credit the Yukon region with a gold production valued at $9,300,000, or considerable more than half of the total for the Territory. The greater part of this comes from the Fairbanks district and bears evidence of the continuous prosperity of this camp in spite of the setback due to the disputes between miners and operators. There was considerable activity in several of the old districts, notably at Fortymile, Birch Creek, and Rampart. Two new districts, the Chandalar and Innoko, have become small producers since 1906.

FAIRBANKS DISTRICT.

The falling off in the gold output of the Fairbanks district from about $9,000,000 in 1906 to about $8,000,000 in 1907 will no doubt be interpreted by those unfamiliar with the conditions as evidence that the district has passed its zenith of production. This is, however, eminently not the case. Had it not been for the labor difficulties, which practically put a stop to the larger mining operations during the months of May, June, and July and seriously hampered them during the balance of the summer, the output of the Fairbanks district in 1907 would undoubtedly have exceeded that of the previous year.

It can not be denied that the richest pay streaks at the scenes of some of the earliest discoveries—such as the upper part of Cleary Creek and parts of Fairbanks Creek—have been worked out, but other discoveries have more than made up for the decreased production from these areas. It is also true that there are large gold reserves in the lower grade gravels which have not yet been touched. It must be admitted, however, that the cost of mining has not been materially reduced since the early days of the camp, and that, until cheaper methods are devised, much of the lower grade gravel can not be profitably exploited. As a matter of fact, the average operator in the Fairbanks district has been so accustomed to exploiting bonanzas that he is very loath to attempt to mine any pay streaks containing lower values. As the bonanzas are of moderate extent, it would appear to be very desirable to improve the methods of mining during the prosperous days of the camp, rather than to wait, as has been done in the Klondike, until these rich pay streaks are exhausted, and thus suffer the years of business depression which must undoubtedly come while the camp is adjusting itself to the new conditions. There appears to be an unfortunate tendency in the camp as a whole to gut the richest deposits, leaving the partly worked out claims for future operators to mine systematically. This is especially true where mining has been done by laymen, who can not be expected to look after anything except the immediate necessity of taking out as much gold as possible, and who care nothing about the condition in which the balance of the unworked material is left. That this is a suicidal policy for the claim holders no one familiar with mining conditions can deny. That it is a necessary evil in the early days of any placer camp is equally certain to all those who have followed the development of mining in the North. It seems, however, that the time has come when some reforms might well be introduced in the Fairbanks district, and that the larger property owners should look to the future as well as to the present.

The greatest need in the Yukon camps, and especially at Fairbanks, is more miners and prospectors. The population of the Fairbanks district and immediately tributary areas can probably be roughly estimated at about 6,000 persons, which is not sufficient to work the ground already opened up, let alone to prospect the areas known to be more or less auriferous. It appears as if there ought to be good opportunities for at least as many more experienced miners and prospectors as are now in the district.

To this 6,000 (estimated as a more or less permanent population) there are to be added several thousand people who annually visit Fairbanks, spending the open season. Probably the chief thing which has deterred laboring men from going to Fairbanks is the high cost of transportation from Puget Sound ports.

As nearly as could be learned by the writer, the difficulties between the miners and operators last season were as follows: The miners demanded a reduction of hours from ten to eight for a day's labor, and an increase of wages from \$5 to \$6.[a] The operators offered to continue the ten-hour day with wages of \$6 or reduce it to eight hours with a wage scale of \$5. The miners demanded a recognition of the union, which the operators declined to grant. The strike was called on April 26, just at the time when the sluicing season began. Most of the operators stood firm, and nearly all work was suspended. As a consequence, the water available for sluicing at the time of the spring run-off was lost, and many of the winter dumps were not sluiced until late in the fall. During the summer, however, some operations were begun again, and late in the fall many claims were running at full blast. It appears that an increase of wages was granted by many of the operators, but there was no formal recognition of the union.

In justice to both sides of this dispute, it should be noted that most of the mining at Fairbanks is by drifting, and that the labor is exceedingly arduous and requires more skill than the ordinary open-cut methods, where anyone who can use a pick and shovel can be employed. On the other hand, an eight-hour day would require three shifts, if continuous operations are carried on. Moreover, there can be no doubt that if the operators are forced to pay higher wages the margin of profit will be absorbed, and much ground can not be exploited. If the eight-hour day and \$6 wage prevail, it means a very material reduction in the area of gold-bearing gravels which can be profitably exploited. Apparently the only hope of reduction in costs at present is in the item of transportation from the outside, both for passengers and freight.

After the strike was called a large number of the miners left for the newly discovered Innoko placer district, this number amounting, according to some estimates, to as many as 1,200. Many of these men did not return to Fairbanks, and as a consequence there was a shortage of labor all through the summer months. So, even had the strike been settled, it is not probable that the mines could have been run at full force. In spite of these adverse conditions, the gold production was large, showing that, could the labor difficulties have been avoided, the output would have exceeded that of 1906. The open season for mining, which usually extends from the last week in April to the latter part of September, in 1907 was continued into October. This fact very materially increased the gold production for 1907 and nullified the value of all estimates of the output made in September, for probably upward of a million dollars worth of gold was taken out after the usual time of closing the mining season.

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[a] This means per day with board.

The general prosperity of Fairbanks is made abundantly evident by the large amount of business which is carried on. About 20,000 to 25,000 tons of freight are annually brought in from outside points. The lumber cut by the local sawmills exceeds 5,000,000 feet. About 200 boilers are annually sold to mine operators, aggregating about 3,500 horsepower. The total horsepower of the boilers used on the creeks in the vicinity of Fairbanks in 1907 is estimated at over 7,000.

The occurrence of gold in the Fairbanks district is fully described in a report now in print,[a] so it will not be necessary to do more than outline the subject here, especially in view of the fact that the geology of this area is to be studied in detail in 1908.

Among the discoveries of the last year perhaps the most significant was the finding of values on Our Creek and in the Smallwood basin and of auriferous gravels on Alder Creek, a tributary of Cripple Creek, and on the lower part of Goldstream Creek. These discoveries considerably extend the known auriferous belt, though the commercial value of this increased area may still have to be proved. Another important discovery is the finding of gold in the upper basin of the Big Chena, which would fall within the easterly projection of the Fairbanks belt. The intervening area would appear to be a favorable field for careful prospecting.

As defined by these new discoveries, the known auriferous zone of the Fairbanks district proper is embraced in an area of 350 to 400 square miles, extending from Esther Creek on the southwest to Fairbanks Creek on the northeast, with a width ranging from 10 to 15 miles. So far as known, the same general geologic conditions prevail both to the northeast and to the southwest of this belt, and there is reasonable hope that the productive area may be found to include a larger zone. There is at least sufficient evidence to warrant the prospecting of the extension of this belt, which, on the one hand, will include the lower valley of Goldstream Creek and its tributaries, where some gold has been found, and, on the other, the basin of the Little Chena. The absence of bed-rock exposures makes it almost impossible to forecast the geology until the mining operations have pierced the heavy alluvial flooring of the valleys. These suggested extensions of the auriferous fields are, however, borne out by what is known of the bed-rock geology, also by the alluvial gold which has been found in the Fish Creek basin and by the prospects reported from Goldstream Creek near the canyon.

In 1907 Cleary, Fairbanks, Dome, Vault, Esther, and Goldstream creeks and their tributaries were the chief producing creeks of the district. Cleary still holds the first place in value of production, with Esther second and Goldstream and Dome ranking next. The finding of placers on Our and Smallwood creeks indicated a broader belt than has been previously supposed. Worthy of special note are the placers developed last year on Vault Creek, which had previously been unproductive. On nearly all the producing streams tributary to the Chatanika the pay streak has been traced well down to the main river.

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[a] The Fairbanks and Rampart quadrangles, Yukon-Tanana region, with a section on the Rampart placers by F. L. Hess: Bull. U. S. Geol. Survey No. 337, 1908.

On Fairbanks Creek there was no notable development during 1907, but operations were continued down as far as claim 10 below Discovery. On Cleary Creek the interest was centered in the operations which were carried on in the Chatanika Flats, near the mouth of the creek. Much mining was, however, done on the upper part of the creek also. On Dome Creek the pay streak was traced down into the Chatanika Flats, and the largest production was from this part of the valley. In September about eight groups of claims on Vault Creek were being operated in a large way. Goldstream Creek, which has been found to carry placers for the upper 7 miles of its course, made one of the large outputs of the district. Many of its tributaries also contain workable placers. Esther Creek, which, previously, had been a comparatively small producer, took second rank in 1907. In fact, the latter part of the summer it was the scene of greater activity than in any other part of the district. Cripple Creek, to which Esther Creek is tributary, carries gold, but so far only a series of bench claims about a mile below the mouth of Esther Creek have been productive. It seems as if the rest of the creek would be worth careful prospecting, but the width of the valley floor has deterred many operators from searching for the pay streak. Alder Creek, a westerly tributary of Cripple Creek, was carefully prospected last year, but it was not learned by the writer whether values were found. An event of special import was the discovery of gold on the bench on the east side of Esther Creek. Though this bench is not definitely proved to carry commercial values, yet it is suggestive of a further extension of the mining operations in this stream valley. The upper part of Smallwood Creek, a tributary of the Little Chena, has been prospected for several years, and a little gold taken out. In 1907 more prospecting was done and some values were found on the creek. Of more interest, however, is the fact that gold was discovered about 5 miles below at a depth of 320 feet. It was not known at the time of the writer's visit whether these deposits are of commercial value, but they indicate a wide distribution of the alluvial gold and suggest at least an extension of the district in this direction.

Among the smaller creeks which have become producers in 1907 is Little Eldorado, where there was a small output. Our and Big Eldorado creeks also made small productions, as did a number of other tributaries of Goldstream Creek.

The lines of development during the next few years would seem to be in the direction of further prospecting on the lower part of Goldstream Creek and on Smallwood Creek beyond the point where commercial values have been found, and the prospecting of the Chatanika Flats to look for old channels of streams tributary from the southeast—that is, buried and abandoned channels of the present drainage system. It is also suggested that it might be profitable to prospect both the streams lying southwest of Esther Creek and those tributary to the Little Chena, which would fall into the general extension of the auriferous belt, so far as it has been outlined. Above all, the systematic effort should be made to reduce the cost of extraction, thus making available large bodies of auriferous gravel which now must remain untouched.

Mr. Covert elsewhere in this report (pp. 198–205) discusses the water conditions at Fairbanks. It is not necessary to repeat this matter here, except to emphasize again the point that, even under the best conditions, there is not sufficient water to carry on all the mining projects. It seems probable that there are possibilities in the development of electric power in some of the adjacent stream basins which might be utilized in reducing the cost of mining. The outlook for bringing in water by ditches, as pointed out by Mr. Covert, is not favorable.

CHENA-SALCHA REGION.

Chena and Salcha rivers are large northerly tributaries of the Tanana which are confluent within 30 miles of Fairbanks. Their sources lie in a region of high relief 30 or 40 miles north of the Tanana, where their headwaters interdigit with streams tributary to Charley River and Birch Creek. According to Prindle,[a] the bed rock of their lower courses is chiefly mica and quartz schist, but in their headwaters there are known to be some large areas of granite.

The northerly tributaries of the central part of the Salcha and the adjacent portions of the Chena basin to the north are auriferous, and some workable placers have been opened up. This gold-bearing district lies about 50 miles east of Fairbanks and is reached either direct by trail or by steamer to the mouth of the Salcha and then by poling boat and overland. The first discoveries in this district were made on Butte and Caribou creeks in 1905.

Of the streams tributary to the Salcha, Butte and Caribou creeks are the most important. On these streams the alluvial floor averages about 25 feet in thickness, of which 18 to 20 feet is gravel. The gold is of a higher value than that of the Tenderfoot district described below, and the deposits are not so deep, but up to the present time the output has been small.

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[a] Prindle, L. M., Description of Circle quadrangle: Bull. U. S. Geol. Survey No. 295, 1906, Pl. I.

Interest in the Chena basin to the north was started by the reported discovery of gold in 1906, but there was relatively little work done until 1907. The gravel deposits are said to be not as deep as those of Fairbanks. It is too soon to forecast the future of this district, but the outlook appears to be encouraging.

TENDERFOOT DISTRICT.

The name Tenderfoot is generally given to an auriferous area lying about 60 miles east of Fairbanks, tributary to Tanana River and including Banner, Shaw, and Tenderfoot creeks. It may be reached by steamer up the Tanana to Richardson and thence by pack trail. This field has been one of active prospecting for a number of years, and a considerable amount of gold has been produced. During 1907 the gold output had an estimated value of $325,000.

The bed rock of the region, according to Prindle,[a] is chiefly mica schist, with some granite and crystalline limestone. Tenderfoot Creek, which, up to the present time, has been the largest producer, is about 6 miles in length. The alluvium is 40 to 100 feet or more in depth, of which about 36 to 80 feet is muck. The deposits on Banner Creek, which joins the Tanana a few miles below Tenderfoot Creek, are of similar character. The most striking feature of these deposits is the low value of the gold, as it carries a very high percentage of silver. It runs on an average about $13 to the ounce.

BONNIFIELD AND KANTISHNA REGIONS.

The Bonnifield and Kantishna placer districts lie south of the Yukon and close to the foothills of the Alaska Range. They were described in last year's Progress Report by Prindle[b] and therefore it will not be necessary to consider them in any detail here. The Bonnifield district is characterized as a whole by very heavy terraces of gravel which are somewhat auriferous. It appears that this gold has in places been concentrated in the present creek bed by natural sluicing, and these deposits have so far formed the workable placers of the district. The gold production of the Bonnifield district has been small, and no very rich or extensive placers have been discovered. The future of the district seems to rest on the possibility of working large bodies of gravel. The nearness of the placer deposits to the high mountains, which should afford a water supply, has led to some investigations looking to the introduction of hydraulic plants. Preliminary examinations of this district were made during the summer of 1907 by engineers representing capitalists.

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[a] The Yukon placer fields: Bull. U. S. Geol. Survey No. 284, 1906, p. 123.

[b] The Bonnifield and Kantishna regions: Bull. U. S. Geol. Survey No. 314, 1907, pp. 205–226.

The Kantishna district embraces an area lying within 20 or 30 miles of the base of Mount McKinley, but in streams tributary to the Tanana. This area was the scene of great excitement two years ago, and some gold was taken out, but chiefly from one creek. Since 1906 there has been very little activity in this district, though probably a dozen or so men have continued prospecting and a little sluicing has been done. The inaccessibility of the region has rendered the cost of mining very high. Over much of the district the gravel deposits are very deep, and it seems to be rather exceptional to find shallow deposits which can be worked by hand methods. For the present the outlook for mining does not seem hopeful.

The entire production of the Kantishna and Bonnifield districts for 1907 was probably less than $20,000 in value.

CHANDALAR AND KOYUKUK DISTRICTS.

A belt of metamorphic rock lying north of the Yukon stretches westward from the Chandalar into the Koyukuk Valley, and has in places been found to be auriferous. The Koyukuk has been a gold producer since 1899, but mining has always been handicapped by the heavy cost of operating. The geology and mineral resources of this district have been described by F. C. Schrader on the basis of his investigations made in 1899[a] and in 1901,[b] since which time there has been no opportunity to send a party into it.

The producing creeks in the Koyukuk district in 1907 were Myrtle, Blake, Emma, Smith, Nolan, Fay Gulch (a tributary of Nolan), Vermont, Swift, Julian, Gold, and Mascot creeks. Myrtle and Emma creeks in this district are worked by open-cut methods, but most of the other streams are worked by drifting. Smith, Emma, Nolan, and Myrtle creeks are said to be the largest producers. It is reported that some very rich gravels were found on Nolan Creek at a depth of 125 feet in November, 1907. This discovery has stimulated mining and prospecting in all parts of the district.

Transportation to this district is uncertain and very expensive. Steamers make three or four trips a year up as far as Bettles—a distance of about 500 miles from the mouth. From that point supplies are taken up in winter by sleds and in summer by poling boats about 100 miles farther to Coldfoot, which is near the producing creeks. It is estimated that about 200 men work in this district, and the output ranges from $100,000 to $125,000 in value annually. The excitement in regard to the Chandalar district took many of the operators out of the Koyukuk region, and hence the production in 1907 was probably somewhat less than that of 1906. It is estimated to have a value of about $100,000.

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[a] Schrader, F. C., A reconnaissance along the Chandlar and Koyukuk rivers in 1899: Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 2, 1900, pp. 471–485.

[b] A reconnaissance in northern Alaska: Prof. Paper U. S. Geol. Survey No. 20, 1904.

In 1906 gold discoveries on the Chandalar were reported, and in 1907 there was a large stampede into this district. The scene of discovery is said to be on Big Creek, a tributary of the north fork of Chandalar River. It is of interest in this connection to note that Schrader pointed out the fact eight years ago that the gravels of this district were auriferous, though, of course, as there had been no prospecting, he could not determine whether commercial values were present.

According to the statement of S. J. Marsh, United States commissioner of the Chandalar precinct, dated November 14, 1907, at Caro, values have been found on three creeks in the district. About 100 men were engaged in prospecting and mining, but only 21 were working claims. Five claims were worked, and the estimated production is valued at $28,000. During the winter of 1907–8 twelve boilers were placed in position for operation on deep ground, and it is probable that 75 men will be engaged in prospecting and developing work during the winter on eight different creeks. The district is reached by steamer, which runs up the Chandalar for about 100 miles.

GOLD ON THE LOWER YUKON.

Much of the bed rock of the lower Yukon (which will here be made to include that part of the river below the mouth of the Tanana) belongs to the coal-bearing series, and hence is not auriferous. There is, however, a belt of metamorphic rocks which stretches from the Tanana parallel to the Yukon on the north, and this touches the river at a number of places. Some metamorphic rocks also lie to the south of this part of the river, but less is known of them. Spurr[a] described a quartz vein which he observed at Gold Mountain, 25 miles below the mouth of the Tanana, and which carried some gold and silver. This part of the belt, therefore, has long been known to be auriferous, but up to last year no values have been found in the gravels.

During the summer of 1907 there was a reported discovery of placer gold in the so-called Goldhill region, about 35 miles below the mouth of the Tanana, on the north side of the Yukon. The discovery is reported to have been made about 15 miles from the river, and the gold is said to have been found on a creek called Columbe, which is said to have yielded wages, under shovel methods. Lower down on the creek, it is reported, a hole 119 feet deep was sunk without reaching bed rock.

There was a reported discovery of placer gold on Ruby Creek, which enters the Yukon from the south about 30 miles below Kokrines. Ruby Creek is about 2 miles long and surface prospects of 2 cents per pan are reported. Some open-cut work was done in the summer of 1907 and is said to have showed good values on bed rock. It is said that about 30 men were prospecting the placers in this district.

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[a] Spurr, J. E., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 293.

INNOKO REGION.

Several years ago there was a reported discovery of placer gold on some of the streams which are tributary to the Innoko in the region lying south and west of the lower Yukon. These discoveries appear to have been made by trappers and attracted but little notice. During the winter of 1906–7, however, news came from the Innoko of the finding of rich auriferous alluvium in this area. This report became current at Fairbanks just at the time when the labor troubles found a large number of dissatisfied men, and for this reason many were attracted by the new find. It is estimated that 1,200 men started for the Innoko, and of these probably 400 or 500 reached the scene of discovery.

The Innoko Valley has never been examined by the Geological Survey; in fact, it is unsurveyed, except for the work done by Lieutenant Zagoskin,[a] who traversed a part of it in 1843. The writer has compiled the following data from various reliable sources. He is under special obligations to Charles F. Ramsden, of St. Michael, and to E. N. Welter, of Fairbanks, who furnished notes and sketch maps, also to W. A. Vinal, United States commissioner for the Innoko district, resident at Moore City, who furnished a statement regarding the mining developments.

The Innoko, the largest easterly tributary of the lower Yukon, discharges into the main river through two channels, one about 30 miles above and the other about 30 miles below Anvik, near the Holy Cross Mission. The lower river is said to traverse a broad flat, fairly well covered with timber and, to judge from descriptions, 50 or 60 miles wide. Above this flat the Innoko occupies a broad timbered valley. The lower part of the Innoko has an exceedingly tortuous course, with very sluggish current. The distance from the Yukon by the river to Deekakat, an Indian village and the upper limit of steamboat navigation, is estimated to be more than 200 miles. However, as this point is probably not over 60 miles in an air line from the mouth, the distance by water is probably less than that estimate. A small river enters from the east at Deekakat, and 20 miles above the Innoko receives another eastern tributary called the Deetna.

About 25 or 30 miles up the Deetna are a number of creeks on which some gold is said to have been found. The most important discovery of gold, however, is on Gains Creek, which is tributary to the Innoko, at a distance of over 200 miles from Deekakat, as estimated by prospectors. A comparison of the maps would indicate that this distance was probably between 75 and 100 miles, though, as the river is here also very tortuous, it is quite likely that the actual distance by river is very much greater. During the spring freshet steamboats are said to be able to go up the main Innoko for at least 100 miles above Deekakat.

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[a] Ueber die Reise und Entdeckungen des Lieutenant Zagoskin im Russischen Amerika: Archiv für wissenschaftl. Kunde von Russland von A. Erman, Berlin, 1848, vols. 6 and 7.

Gains Creek and the headwaters of the Deetna are separated from the Kuskokwim waters by a high mountain ridge on which there is reported to be some permanent snow. This would indicate the high altitude of the range and suggest that a water supply for sluicing purposes could be had all through the summer months. The summer of 1907 was exceedingly wet in the Innoko district, and it is probable that the rainfall here is much greater than in the upper country.

The bed rock of the country is said to be chiefly slate, with some quartzite, and in the mountains some granite. Between the upper Innoko and the Yukon there is said to be a belt of mica schist. A little impure lignitic coal is reported on the lower river.

There is said to be a portage from the head of the Innoko north of James Creek to the Kuskokwim. The actual carriage is supposed to be a distance of only 7 miles. Deekakat is said to be about 75 miles, or three days' travel in winter, from Kaltag, on the Yukon.

The discovery of gold was made on Gains Creek and on a bench which is 8 or 10 feet above the water level. During the summer of 1907 four claims are said to have been opened up. The gold which was taken out (estimated at between $10,000 and $20,000) all came from benches on this creek. The gold is said to be coarse. The floor of the creek to bed rock is said to be 15 or 20 feet deep, all of which is gravel. The ground for the most part is unfrozen, and the presence of live water makes prospecting difficult. Newspaper accounts report the discovery of values in the bed of Gains Creek during the winter of 1907-8. On Madison Creek a depth of 31 feet to bed rock is reported, of which the upper 9 feet is clay or muck, overlying well-assorted gravel, and some gold has been found, though not in commercial quantities. A little gold has been found on the bars on the Innoko some distance below the mouth of Gains Creek. The trees on the creeks are scattering and scrubby, but fairly good timber is found on the main river.

Of special interest is the reported discovery of an auriferous quartz ledge on Gains Creek. In this the gold is said to be free and to carry good values. A shaft sunk about 30 feet did not reach solid bed rock, and up to this depth the ledge was very ill defined.

Probably 500 men were in the Innoko region during the summer 7, but most of them spent their time in staking claims and in moving supplies, and little prospecting was done. It is reported that about 200 men will winter in the Innoko region. During the summer of 1907 the cost of freight to Gains Creek from Nome was about $400 a ton. Winter rates for freighting from the Yukon were 50 cents a pound.

It is worthy of note that there have been reported discoveries of gold in the region lying east of the Innoko, in the Kuskokwim basin. There can be no doubt that during the coming two years this country will be thoroughly prospected and the finds that have been made would seem to warrant further search.

RAMPART-BAKER CREEK REGION.

The area generally known as the Rampart district embraces the streams tributary to Minook Creek, and also the area south of the divide, including Glenn and other creeks lying in the Baker Creek basin. Now that the southern part of the field has become the larger producer, the name Rampart no longer appears to apply. The year 1907 saw great activity in this district, but the larger part of the production came from the southern half of the area.

In the northern part of the field one hydraulic plant was at work on Hunter Creek, and considerable sluicing and some drift mining were done on the other creeks of this part of the district. The most important developments, however, were made in the southern part of the area, particularly on Thanksgiving Creek. A ditch was built from California and Alder creeks to Thanksgiving Creek, giving an 80-foot head at Discovery claim. Another ditch was built to Glenn Creek from the head of Pioneer. Considerable prospecting was also done in this area, with the aid of a diamond drill, which was found to be a very economical method of operation. Plans are under way for building a ditch to Pioneer and Eureka creeks from the head of Hutlina Creek, near Montana Creek. This ditch is to furnish water for all the benches from Glenn Creek to New York Creek.

Some auriferous gravels were found during the summer of 1907 on Patterson Creek, tributary to the Tanana. The scene of the discovery is at the mouth of Easy Money and Sullivan creeks and near the trail leading from the Hot Springs to Fort Gibbon. The bed rock is chiefly slate and is covered by gravels 35 to 70 feet deep. The gold is said to be similar in character to that found on Glenn Creek, and its location suggests that this deposit may be a southwesterly extension of the Glenn Creek belt. If this is so, it would be worth while to prospect the general extension of the same belt to the southwest. Though there was no actual mining in the summer of 1907, sufficient gold appears to have been found to warrant further careful prospecting in this field. Several boilers were put on the creek during the summer of 1907, and it will probably be pretty well prospected during the winter of 1907–8.

It is estimated that between 500 and 600 men were engaged in prospecting and mining in the Rampart-Baker Creek district during the summer of 1907, and considerable mining was also done during the winter months. The total output of the district is estimated to be somewhat over $300,000. Its accessibility to the Tanana and Yukon, especially since roads have been constructed from both Hot Springs and Rampart, gives it the advantage over a number of the Yukon camps.

BIRCH CREEK REGION.

The season was rather dry in the Birch Creek district in 1907, and the gold output was somewhat less than in the previous year. Deadwood Creek and Mastodon Creek and its tributaries continue to be the chief producers of the district. No new enterprises were inaugurated on the north side of the divide in 1907. Prospecting on the lower part of Deadwood Creek developed some interesting facts. Twenty holes were sunk at depths of 14 to 20 feet on the flats, but no bed rock was reached and the ground was found to be unfrozen. Gold is said to have been found throughout the whole body of gravel, except in the upper 3 feet, and estimates of values are reported at 40 cents to $1.50 a cubic yard. It would appear that this creek would be worthy of further investigation with a view to handling the ground by dredges.

On the south side of the divide considerable developments were made on Eagle Creek, where two ditches were constructed, bringing water from both forks of the main creek for hydraulic purposes. Mining continued in a small way on Woodchopper, Fourth of July, and other streams tributary to the Yukon. The estimated value of the production of the Circle precinct for 1907 is $200,000.[a]

COAL MINING.

The accompanying table shows the production of coal in Alaska since coal mining first began in 1888. The figures for years previous to 1898 are only approximations, as no accurate statistics were collected up to that time. The later years, however, are represented by statistical data collected in large measure by actual correspondence with the producers. Up to 1906 most of the coal produced was of a lignitic nature, though some subbituminous coal was mined on the lower Yukon and at Cape Lisburne several years ago. The delay in procuring patents on Alaska coal lands has seriously hampered the coal-mining industry, and until the legal questions are settled no considerable advances can be expected.

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[a] The Fortymile district is discussed in another section of this report by Mr. Prindle. (See pp. 187–197.)

Production of coal in Alaska, 1888–1907.

Year.	Amount (short tons).	Value.
1888-1896	6,000	$84,000
1897	2,000	28,000
1898	1,000	14,000
1899	1,200	16,800
1900	1,200	16,800
1901	1,300	15,600
1902	2,212	19,048
1903	1,447	9,782
1904	1,694	7,225
1905	3,774	13,250
1906	5,541	17,974
1907	5,150	27,850
	32,518	270,329

NOTE.—The production for 1888-1896 is estimated on the best data obtainable. The figures for the years subsequent to 1898 are based for the most part on data supplied by operators.

In 1907 there were only three coal producers in Alaska, as compared with five in 1906. One important advance was made, however—the first attempt at developing the high-grade coals of the Controller Bay region. Considerable coal was mined on Bering Lake for local use, and its production was of very material benefit to the railway construction which was going on in the vicinity. The reported easterly extension of the Controller Bay coal fields is worthy of note. Coal is reported to have been found in the high ranges back of Bering Glacier and also near Yaktag. In the Controller Bay field as a whole prospecting has also been actively pushed, and the promise of a railway which is soon to reach the coal fields will accelerate the work in this region. In the Matanuska field much prospecting has been done, including some driving of tunnels. A mine in Seward Peninsula continued to produce coal for local use, and one small mine was running on Alaska Peninsula, also to supply a local demand.

The lignite from the Yukon has been entirely neglected for the last two years—that is, since the introduction of oil-burning engines on the river steamers. This is to be regretted, because some of the lignites would undoubtedly furnish a valuable source of fuel, if they were systematically developed. On the Canadian side of the boundary a considerable amount of the same grade of coal is mined and used at Dawson and other points. On the Alaska side no coal was mined in 1907, and as a consequence there was a proportionate devastation of the rather meager supply of timber. The Fairbanks district alone is estimated to use 35,000 cords of wood every year. The lignite coal field, lying on the upper waters of the Nenana and stretching farther eastward toward the Delta, should furnish a valuable coal supply, even though the coal is of low grade, were it opened up by a railway. It seems only too likely that the time will come when the Alaskan placer miner will feel the pinch for fuel, and then he will have to depend on the lignite coals. It is even already noticeable that in many older camps the timber is getting very scarce. Much has been used for mining purposes and a far larger amount has been destroyed by forest fires.

The Alaska coal fields, particularly those carrying a high-grade fuel, like the Controller Bay and Matanuska fields, are destined to play an important part in the advancement of industry on the entire Pacific seaboard of the North American continent. Their early opening up is therefore a vital question to all residents of the Pacific coast.

PETROLEUM.

There have been no developments in the petroleum industry in Alaska in 1907. Two of the wells which were drilled several years ago at Controller Bay, however, were pumped and furnished a local supply of petroleum for use in railway construction. Some further prospecting with drills was also done but does not seem to have yielded any very definite results. So far as learned, no work whatever has been done in the last two years on the Cook Inlet fields.

BUILDING MATERIAL, ETC.

The appended table shows the value of the production of gypsum and marble since mining of these products was begun in Alaska.

Value of marble and gypsum produced in Alaska, 1901–1907.

1901	[a] $500
1902	[a] 255
1903	[a] 389
1904	1,700
1905	710
1906	11,995
1907	71,958
	87,507

The quarrying of marble has become an industry of some importance in the Ketchikan and Wrangell districts, and in the Sitka district the production of gypsum is increasing. Owing to the fact that there are only a few producers of these two minerals, it is necessary to group them together in the production tables, so as to avoid giving any clew to individual outputs. It will be noted that the value of the production for 1907 is almost three times that of 1906. These mineral deposits are described at some length by Mr. Wright (pp. 116–175), and it will not be necessary to consider them further here.

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[a] Estimated.

Among the nonmetallic minerals of value should be mentioned mineral water, which has been produced in a small way in southeastern Alaska. Hot springs are not uncommon throughout Alaska, and many of them have been utilized both as local health resorts and as centers of gardening, notably the Baker Hot Springs in the Tanana Valley and the Hot Springs in the Kuzitrin Valley, Seward Peninsula. During past years the actual bottling of mineral waters has been attempted only in southeastern Alaska, and so far as known, there was no production in 1907.

Mr. Smith elsewhere describes some occurrences of graphite in Seward Peninsula. (See p. 250.) These deposits have not been developed, but appear to give promise of having a possible commercial importance. Mica has also been found in the Council region of Seward Peninsula, but it is not known to be of commercial importance, though some large slabs have been brought out. Asbestos has been found by Mr. Prindle at a locality in the Yukon-Tanana region (see p. 25), but is entirely undeveloped.

PROSPECTING AND MINING GOLD PLACERS IN ALASKA.

By John Power Hutchins.

INTRODUCTION.

During the last decade placer-mining operations in Alaska have developed from the crude methods of the pioneer, whose implements often consisted of little more than the shovel, the pick, and the whipsaw, to modern well-equipped plants, representing investments of many thousands of dollars. Like all other industrial evolutions, this development has not been without its failures. Inasmuch as the financial loss entailed by such unsuccessful enterprises has often been great, and as many of them might have been prevented by a more thorough knowledge of conditions prevailing in the north, it will be in the interest of those engaged in or contemplating placer mining to present briefly some of the essential facts bearing on the systematic exploration of Alaskan placers.

It is to be regretted that data respecting the tenor of gold per cubic yard and the working cost per cubic yard under varied conditions are not more generally kept and published by the operators. Such records could not fail to be of value in the exploitation of gravels under similar conditions elsewhere. Comparison of records would carry much weight where a number of miners were operating under similar conditions, but by different methods.

Among the many factors which influence the commercial success of placer-mining operations, those of general application will be considered in detail. It is evident that location, with which is involved the whole problem of transportation and therefore costs, is a dominating factor. Climate, involving length of working season, rainfall, condition of alluvium, timber, etc., is another. Topography, as affecting stream gradients, and hence dumping ground, and the installation and maintenance of reservoirs and ditches to conserve and conduct water for placer work, has the closest relation to mining cost.

The factors above outlined may be said to be the geographic conditions affecting all placer enterprises. The extent, character, and distribution of the auriferous alluvium, the character of the bed rock, the distribution of metallic content, and peculiarities of pay streak and of overburden are matters that must be determined in detail for each deposit. In the final analysis of a property it may be found that the gold content per cubic yard alone will determine the possibility of successful exploitation, for, if this is high enough, practically all the other factors may be disregarded. The present paper, however, is not intended to treat of bonanzas, but of large bodies of auriferous gravel the gold content of which is such that they can be worked profitably only by the exercise of the miner's skill and business acumen. Any peculiarity that bears on the working cost is important and should have as great weight in determining the value of a property as the gold content.

In the discussion which follows, intended primarily for those unfamiliar with the conditions in Alaska, the subject will be treated from the technologic as distinguished from the geologic point of view. This paper can not pretend to be a complete statement, and therefore while certain methods such as prospecting with churn drills, dredging, etc., of which the writer has made a special study, will be treated at some length, other modes of testing and exploiting placer ground will be discussed very briefly.

FROZEN GROUND.

The extent and distribution of the ground frost in Alaska and other northern countries may become a governing factor in counting the working cost of an enterprise, especially of one in which the operation of mechanical excavators is contemplated. There are two kinds of frozen ground in Alaska—(1) that which is permanently frozen and (2) that which is subject to superficial freezing in winter but thaws during the summer. Both are a great hindrance to mining operations. For example, in general permanently frozen ground can not be dredged profitably. It is likewise an obstacle to the erection of dams, ditches, bridges, buildings, etc. Seasonal frost is less prejudicial, but may seriously hamper dredging by curtailing work for many days each season.

The only kind of mining that is even in part benefited by frost is drift mining. It is possible to drift frozen ground that could not be mined except at a prohibitive cost for pumping and timbering were it unfrozen. Deep deposits of drained gravel can be drifted more cheaply if unfrozen, except where timber is so scarce that its cost would be greater than that of thawing.

Permanent frost is the normal condition in Alaska except in the Pacific coast region. Observations made by the writer indicate that permanent frozen ground is generally found in the beds of small streams and it may be present at irregular intervals even in the beds of large streams. Frozen ground is often found in the flats of a stream valley adjacent to the unfrozen stream bed even though the stream carries several hundred second-feet. Wherever there is an overburden of muck or tundra, it is almost certain that frozen ground will be found beneath it. A growth of willows on Seward Peninsula is said to be an infallible index of unfrozen ground beneath, and this is generally though not invariably true.

Seasonal ground frost penetrates each winter to a depth of 6 to 10 feet or more in the stream beds, and dredging operations in the early part of the working season are handicapped by this blanket of frozen material. It thaws but slowly, and therefore interferes with the work during a considerable part of the season. When it partly thaws it often leaves a frozen stratum 1 to 3 feet in thickness which sometimes breaks down in large slabs that are troublesome to handle.

No accurate or detailed data in regard to ground temperatures in Alaska are available. All that is known is that some ground is frozen and other ground is not. Investigations and records of the ground temperatures of both frozen and unfrozen ground would possibly suggest a means of thawing the enormous volumes of material which can not now be profitably worked, but which if thawed would be lucrative. Should such observations result in evolving a cheap means of thawing the consequences would justify a considerable expenditure. The problem of thawing presents discouraging features, but it is not hopeless. The only way to solve it, if indeed it can be solved, is by scientific investigation, coupled with large patience and a knowledge of the mining requirements of the far north.

PROSPECTING.

GENERAL CONDITIONS.

The subject of prospecting will be especially emphasized here, because probably three-fourths of the failures in placer mining are due to the fact that the equipment has been installed before the ground has been properly tested. Millions of dollars have been wasted through this cause and there is still a lamentable tendency to install expensive mining plants with insufficient data as to the real value of the property under consideration. Operations of considerable magnitude are at the present time being undertaken where the gold content or the working cost per cubic yard is not known within 25 per cent of the real figures.

The popular conception of placer mining is extremely hazy. The mind of one who is uninitiated does not readily grasp its complexity. The general idea of a placer pictures a volume of material of no particular size, containing a high gold content, so rich that mining an inconsiderable amount of it will result in large dividends. As a matter of fact, such bonanzas are exceptional, and when they are found the public has no opportunity to invest, for the richness of the bonanza makes it unnecessary to seek outside capital. It may in general be safely concluded that in nearly all the enterprises that are presented for public investment comparatively low grade material is to be exploited. Such material yields only a small advance over the cost of mining. Therefore not only should the value of the metallic content be accurately determined by proper prospecting, but all conditions that influence operating cost should be carefully investigated.

The investigation of placer deposits is not a simple matter, particularly when accurate determination of the gold content and volume of large areas of low-grade material must be made. Such investigations should be carried on by one familiar with the conditions peculiar to the region. A mining engineer whose work has been done in other regions, no matter how capable, efficient, and experienced, is at a great disadvantage in the Far North, where the conditions encountered are in great part unique.

There are a large number of deposits that can be easily prospected by the average miner. Such are the small, rich, shallow placers that lend themselves particularly to one-man methods of operation. These can be investigated at a comparatively low cost, without expensive apparatus, and as the cost of operation is much less than the gold output, refined prospecting and engineering skill are not needed. It is lamentable that failures are being frequently made on such placers, for most of them can be easily avoided if a comparatively small amount of careful prospecting is done.

In lode mining it is usually difficult to determine the valuable content and volume of the lode without a large amount of costly excavating. In most placer mines, however, modern methods make it cheap to ascertain, within a comparatively small margin of uncertainty, the amount of gold in the ground to be exploited. This makes placer mining less of a speculation than lode mining, provided the necessary money is spent to prospect the ground thoroughly. Unfortunately the public at large is slow to realize this fact and the conscienceless or ignorant promoter too often procures financial backing for placer-mine equipment where only a most cursory and superficial examination has been made.

Proper prospecting involves the determination of the following more important factors: (1) Volume of pay alluvium; (2) extent, value, and distribution of pay streaks; (3) character of alluvium; (4) its degree of induration; (5) distribution and character of bowlders; (6) distribution and character of clay; (7) depth of alluvium; (8) depth to ground water; (9) character of bed rock. In addition to these, in Alaska, there is the prime necessity of investigating the distribution and character of ground frost, both permanent and seasonal. All the above factors influence working cost.

It is somewhat difficult to give average costs, for the expense for labor, transportation, fuel, and other items varies greatly in different parts of Alaska. It is safe to assume that in most Alaska placer camps labor and supplies will cost at least 100 per cent more than in the States. It is probable that the figures given elsewhere in this paper may not include the lowest or the highest figures, but they are presented with the hope of emphasizing the great importance of detailed investigation as a preliminary to any mining operations in this region, where, although rich gravel is often found, the working cost may be so great as to prevent success.

To obtain information concerning the various factors which have been enumerated above as influencing the cost of mining, it is necessary to penetrate the placer deposit and thus learn its thickness, condition, and contents. This may be done in one of two ways—by drilling a hole through the gravels or by sinking shafts.[a]

By the drilling method small samples are obtained. Briefly, out of each drill hole a cylinder of material about 6 inches in diameter is obtained from grass roots to bed rock. A prospecting shaft 3 by 6 feet has a cross-sectional area about 50 times as great as that of the drill hole. Thus the volume of material obtained from the shaft is often 50 times as large as that from the drill hole. As a matter of fact, the usual proportion of samples is very much less than this, for often but a small part of the material excavated from shafts is tested. The writer has seen a sample taken from a shaft 10 by 10 feet and 20 feet deep that was actually smaller than would have been obtained in a drill hole in the same ground.

OPERATION OF CHURN DRILLS.

The essential features of the drill method of prospecting are sinking a pipe to bed rock and extracting and testing the material that is included within the pipe. Drilling may be done by machinery run by steam or gasoline engines, or by hand alone, or by combined hand and animal power.

POWER DRILLS.

The steam and gasoline drills are essentially alike in operation and equipment. Inasmuch as the gasoline engine is more delicate, less reliable, and less flexible in operation than the steam engine, it is from these considerations alone inferior, although it may, on account of difficulty of transporting fuel and supplies, be preferable in some places.

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[a] For convenience of treatment all openings that permit the entrance of a man, such as vertical shafts, inclined shafts, drifts, upraises, winzes, vertical, inclined, and horizontal cuts, are included under the head of shafts.

The actual drilling with a power churn drill involves three operations—(1) driving a pipe to obtain a core, (2) drilling this core to prepare it for pumping, and (3) pumping and hoisting this drilled material from the pipe and discharging it into a receptacle for testing. Each of these operations requires changes of tools and manipulation, and they are continued until the hole is finished. First, a heavy 6-inch pipe (weighing 20 pounds or more per foot) is driven into the ground 1 foot at a time by striking it on the upper end with a pair of driving clamps. These are clamped to the stem of the drill, which hangs inside the pipe from a cable sustained on the derrick of the drill by which the driving is being done. The drills, stem, etc., weigh about 1,000 pounds and strike about 55 blows per minute, raising and dropping the tool about 3 feet at each blow, though the length of blow can be adjusted to 18, 24, or 36 inches. It is obvious that a heavy blow can be struck and that the pipe must be strong and well prepared for such hard usage. A drive shoe is screwed to the bottom of the pipe. This is extra heavy and of metal sufficiently tough to penetrate gravel. A driving head is screwed to the top of the pipe to take the blows delivered by the driving clamps.

The cable can be reeled in or out while the driving or drilling or pulling is being carried on. After the pipe has been driven a foot or so, the driving clamps are removed and the core is drilled within a few inches of the bottom of the pipe. The drill is a chisel-shaped tool. Its action is to crush rather than to cut, and it breaks hard material, which is generally brittle, at a rapid rate—1 foot in three to ten minutes in medium-sized loose to coarse indurated gravel. When the core has been drilled it is pumped from the pipe. The vacuum pump, hanging on a different cable from that of the drill, has a length of about 8 feet and an inside diameter of about 4½ inches. A piston operates inside the barrel of the pump in the following manner. The pump is sustained by a rope attached to the piston at the upper end. When the pump is hanging on this rope, the piston is against a stop in the upper end of the pump barrel. In using the pump it is dropped suddenly into the pipe and slack line is allowed to pay out. The piston thus drops to the lower end of the pump barrel. The slack rope is reeled in rapidly, the plunger in sliding up inside the pump barrel creates a partial vacuum, and material is thus sucked in through the bottom of the pump and held by a plain flap or clack valve. When the piston strikes the stop at the upper end of the pump barrel, the pump is picked up and then hoisted from the pipe with its content of water and drilled material. There is an opening in the side of the pump barrel near the top, at such a height that the piston passes above it as it is hoisted to its stop. The pump is then emptied into a receptacle through this opening.

The methods of separating the gold from the materials obtained by drilling will not be discussed here in detail. Ordinarily the sample is panned or rocked, the various characters of the alluvium are observed and noted, the metallic content is saved and weighed, and the average value per cubic yard of the alluvium is calculated.

After the hole is finished the pipe is withdrawn from the ground by pulling. A pulling head is screwed to the top of the pipe, being so arranged that as the drill cable is alternately shortened and lengthened an upward blow is struck by the pulling hammer, which works inside the pipe. A blow almost if not quite as strong as that given in driving is thus obtained and the pipe is pulled from the ground. This is the hardest work the drill has to do and most of the breakages occur during this operation.

Under average conditions, about 10 to 20 feet per day of ten hours can be drilled in this way. The cost of operating a steam drill per day in Alaska is approximately as follows:

Daily operating cost of steam drill in Alaska.

Drill runner	$11	to	$12
Panner	6	to	8
Fireman	6	to	8
Pumpman	6	to	8
Man and team	20	to	25
Total labor	49	to	61
Repairs, renewals, and fuel [a]	10	to	30
	59	to	91

A frozen condition of the alluvium makes peculiar operation necessary. Sinking with a drive pipe in frozen ground is often conducted by drilling about 8 to 10 inches below the drive shoe, driving for 12 inches, and then pumping. As it is difficult to drive in frozen ground and extra heavy pipe must be used, water heated by live steam from the boiler is kept in the drive pipe to prevent its freezing solidly in the ground. The pulling of the drive pipe from frozen ground is difficult and chain blocks are often used.

Frozen ground is frequently drilled by steam drills without using a drive pipe. Such procedure is justifiable only when the drilling is merely to locate a channel. It is not good practice to drill without a drive pipe if accurate determination of the gold content is to be made, as material is sloughed off the sides of the drill hole by the water thrown into the hole during the drilling, and thus inaccurate sampling is done. Drilling without a drive pipe can be done at a cost of less than $2 per foot[a] and as much as 75 feet is said to have been drilled in ten hours.

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[a] About half a cord or its equivalent of other fuel is used per day. Wood costs on the Yukon $6 to $12 a cord; coal at Nome $20 a ton. In one steam-drill investigation on Seward Peninsula coal cost $120 per ton. Transportation governs cost of steam drilling, having a direct effect upon the cost of labor, supplies, repairs, and renewals.

HAND DRILLS.

The hand-drilling outfit consists of a casing (lighter than drive pipe) with a toothed cutting shoe screwed to the lower end. A platform is placed on top of the casing and men standing on the platform operate one of a variety of tools inside the casing, alternately raising and dropping the tool as in churn drilling. At the same time other men rotate the casing by means of poles attached to the platform, or a horse harnessed to a sweep. The casing with its cutting shoe, by its own weight and that of the platform and men standing on it, cuts into the ground, there being but little friction to overcome, as it is kept loose by rotation. A tool which drills and pumps material into its barrel simultaneously is generally used. Thus the casing is sunk and the material is drilled and pumped at one operation, with the same result that is obtained in the three operations of the power drill. Several kinds of pumps are used, equipped with ball or flap valves. The pump fits the casing and as the pump is dropped it causes a rush of water into the barrel from below, the drilled material being carried into the barrel and held there by the ball valve.

The casing is pulled from the ground by leverage; a pole 25 feet or more long can be used. As a matter of fact, it is seldom necessary to use much force, for the casing is rotated while being pulled and it is customary to pull it at the rate of 30 feet or more per hour. It is obvious that there will be less wear, tear, and breakage while using this device than with a steam churn drill. The means of sinking and withdrawing the pipe are easy and effective and they subject the pipe to much less severe usage; moreover, the process is more rapid. The hand churn drill is essentially a combination core and percussion drill. The cutting shoe obtains the core like a core drill, partly preparing it for drilling and pumping, while the tool works simultaneously by percussion on the core and as a pump.

This type of hand drill is well suited to prospecting in Alaska. When equipped to drill 30 feet deep the whole outfit weighs about 1,000 pounds. It makes up into one-man packs with a maximum weight of less than 75 pounds each and so is particularly advantageous in inaccessible districts. It will sink from 20 to 40 feet of 5-inch hole through medium-size gravel in ten hours if not working at too great a depth. It does not work at depths of more than 75 feet without a spring pole or other device to help support the weight of the rod and tool. It requires five to seven men or five men and one horse to run it, depending on the depth being drilled and the method of rotating the casing. Its cost of operation per day, roughly estimated, is as follows:

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[a] This figure is said to be correct for the district near Nome.

One panner, $6 to $8; 5 to 6 men, $30 to $48; total, $36 to $56; or, when a horse is used to rotate the casing, 1 panner, $6 to $8; 4 men, $24 to $32; 1 horse, $3 to $10; total, $33 to $50.[a]

COMPARATIVE MERITS OF POWER AND HAND DRILLS.

Both of these drills have merits in their application to prospecting in Alaska. Rapidity, cost, and accuracy are the three prime considerations in any drill test.

The churn drill operated by steam works more rapidly when actually drilling, and so is well adapted to deep ground where moves are infrequent. Where there are many moves to be made, as in drilling shallow alluvium, particularly where the surface is rough or swampy, the hand churn drill, because of its mobility, will often drill a greater number of feet in a given time than the steam churn drill. the hand drill, however, will not penetrate as large bowlders as will the steam drill.

The cost of operation per day of a hand churn drill in Alaska will be generally less than that for a steam churn drill and the expense for wear and tear and breakage is very much less.[b] There is very little lost time for breakage when using the hand drill.

The more inaccessible the deposit under investigation the greater will be the advantage in favor of the hand churn drill in operating cost.

The first cost of the hand churn drill at the factory is less than one-half that for the steam churn drill. Moreover, freight charges are much greater on the steam drill, which weighs with its equipment ten to fifteen times as much as the hand drill. Transportation into inaccessible districts in Alaska is very costly and a steam drill at its destination may cost several times its factory price.[c]

The core obtained by the hand churn drill with rotated casing is probably more nearly representative of the material being sampled than that obtained by driving the pipe of a steam drill. The hand drill needs but infrequent driving to sink the casing and as the driving is done while the casing is being rotated it has a maximum effect and therefore less is required.

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[a] These figures are based on wages paid in Alaska in 1907. The cost of a horse can only be approximated, as prices vary; the figures given are about the maximum and minimum. These estimates are for Seward Peninsula and the Yukon-Tanana region. In the Pacific coastal regions the cost of labor, etc., is less.

[b] The writer has used this drill where there were no blacksmith shops. A grindstone and files were used occasionally to sharpen tools when necessary, and this was not frequent.

[c] Freight charges at Fairbanks are $75 to $90 per ton; cost of transport to the mines is $30 per ton in winter and $120 in summer. It may be many times this high figure, as much as 20 to 25 cents per pound having been paid. Alfred H. Brooks, in the National Geographic Magazine, says: "Translated into terms more familiar to the average man, this means that the mine operator may have to pay a rate on all his heavy machinery equivalent to the charges for express between New York and San Francisco. In fact, I have known mining enterprises to be carried on in localities to which the transportation charges were greater than letter-rate postage."

It may be said in general that where the deposit to be investigated is deep and accessible to supplies and machine shops and the surface is not very swampy the steam churn drill will do the cheaper and more rapid work; where the ground is shallow, swampy, or inaccessible the hand churn drill will give better results. Even if the hand drill were more costly to operate per day or per foot, it would still be a better and cheaper device for prospecting inaccessible areas where the expense for transportation, renewals, and repairs is very high.

NECESSITY OF ACCURACY IN SAMPLING.

The prime object of the drilling method in testing placer ground is to obtain a sample which is a cylinder of material of a known diameter from the grass roots down to and into bed rock as far as ore[a] is found. A pipe is used to penetrate the deposit ahead of the drilling and pumping tools, being kept far enough in advance so that only the material subtended by the shoe on the pipe will be included in the core. The main essential of any sampling with a drill is to get only the material that is properly the core, neither more nor less. The whole operation must be conducted with this feature in mind, and all else should be sacrificed to attain accuracy in this respect. Any phase of operation that results in getting too much or too little core material introduces errors. The ratio of the volume of a sample from a drill hole to the volume of the material represented by the sample is about 1 to 100,000 when one drill hole per acre is sunk. Any errors are thus largely magnified in the calculations of average gold tenor. In sampling a lode the ratio of the volume of the sample to that of the lode is often 1 to 5,000.

Suppose that the drill operation is being conducted in 50-foot ground. Then the volume of the sample will be about one-third cubic yard, or about 50 pans of material. If the drilling is so done that each of 45 of these pans contains 1 milligram of gold, worth 0.06 cent, which ran in from outside the pipe and does not belong to the core, and if the other 5 pans of material indicate a gold tenor of 10 cents per cubic yard and this is the true average for the sample, then the apparent gold content will be 18 cents per cubic yard. If this hole were supposed to test an acre, it would indicate a gross gold content of $14,520, instead of $8,067, the true figure. This error results by obtaining an excess of gold of a total value less than 3 cents in a drill hole 50 feet deep. Thus a small error in testing ground may lead to a very large error in estimating the value when calculations are made. Such errors have been made in actual practice.

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[a] Ore in its mining sense is material that has a valuable content sufficient to make it profitable to work it.

When large bowlders are encountered while prospecting with either steam or hand drills, it is necessary to drill below the pipe before it can be sunk. When this is necessary the pipe should be sunk through the drilled material before pumping is done, to insure against obtaining material not properly a part of the core.

DRILLING SEASON.

Prospecting by drilling can be done at all times of the year, even in winter. Areas that are marshy in summer can be more easily tested with a steam drill in winter, for then the surface is frozen and the heavy drill can be moved without miring. It is easier to drill a stream bed from the ice when the stream is frozen than to test it with the steam drill from a scow.

Seasonal frost interferes with drilling in winter, but ground permanently frozen can be drilled in winter as rapidly as in summer. Very cold weather is liable to cause inaccuracies in handling material from the pipe. A small tent warmed with a stove affords shelter for the panner and should be used.

RELIABILITY OF DATA PROCURED BY DRILLING.

If extensive work has been done in Alaska at any place where exploitation was preceded by close drilling, the information obtained, so far as the writer knows, has not been published, and therefore figures comparing prospecting and operating results in that Territory can not be given. It is possible, however, to give some data of value from other regions where drill holes have been checked by subsequent exploitation. In regions where ground has been tested by close and systematic drilling, the results of extensive subsequent mining have shown the reliability of this method of prospecting. A great amount of care must be exercised in any prospecting of alluvium in Alaska. Gold occurs generally in extremely irregular pay streaks. Any prospecting, to be reliable, must be of such scope as to delineate these pay streaks and to determine their bearing on the average gold content of the total volume of alluvium under investigation.

When the drill method is used to locate bonanzas and not to make a fair test of large areas of low-grade alluvium, the results give false averages. When prospecting with drills is properly done the results are reliable. Accuracy, however, has been sacrificed to speed in many tests, as where the drilling has been done without a pipe. The drill method has been badly abused and much of the information so acquired will prove unreliable; but there is no reason why drill prospecting should not be as trustworthy in Alaska as in the States, where results attained by well-conducted drilling are accepted without question.

SHAFT PROSPECTING.

Shaft prospecting consists in making openings of such size as permit a personal inspection of the alluvium. Under this general head will be included, for convenience, shafts, inclines, winzes, upraises, drifts, and horizontal, vertical, or inclined open cuts. The advantage of shaft prospecting is obviously that it permits a close inspection of the alluvium and the obtaining of large samples. Any peculiarities of the alluvium and bed rock can be examined in detail. Large samples tend to compensate for irregularities in the distribution of the metallic content and thus are more likely to indicate a true average of the material being tested. The material excavated from the openings is panned, rocked, or sluiced, and its metallic content is saved.

No average can be given for the cost of shaft prospecting, as it depends on the characteristics of the material being investigated. In Alaska [a] it may cost about $1 per foot under the most favorable conditions, or it may cost more than $50 per foot where the conditions are difficult.

The reliability of the shaft method of prospecting is treated elsewhere in this paper (pp. 66–67). Some incongruous work has been done by the advocates of shaft prospecting, many of whom claim that it is a far superior method to that of drilling. They have sunk shafts and other openings of considerable size and then merely panned a very small proportion of the excavated material. The samples so panned were taken with little regard to the requirements for obtaining a fair average, and in a generally unsystematic and irregular way. Such inconsistencies are often seen and the advantage possible in getting large samples by shaft prospecting may be entirely lost by careless sampling of the excavated material.

CHOICE OF PROSPECTING METHOD.

Without regard to the geology, all Alaskan placers may be classified as shallow or deep. For convenience of consideration in this paper, all placers less than 25 feet deep are arbitrarily called shallow. Such placers, at or near sea level, if so wet as to require pumping, can be investigated with shafts while the pump is set on the surface of the ground. The practical limit of suction at sea level is about 25 feet. Placers deeper than 25 feet or of less depth and at higher altitude, if wet, must be drained by sinking pumps to the necessary depth. This necessitates a larger shaft to accommodate the pump, pipes, etc., and obviously will increase the cost per foot.

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[a] In the Fairbanks district shafts about 4 by 6 feet and about 100 feet deep cost on the average about $8 per foot. In frozen ground very little timbering is required, only a few sets being necessary at the collar of the shaft to prevent caving of the surface material under the influence of thawing.

The choice of prospecting method is governed by a number of considerations, some of which are influenced by conditions foreign to the actual prospecting. For instance, a deposit well adapted to investigation by the steam drill may be so inaccessible as to make it good practice to use hand drills or shafts instead. The rapidity, cost, and accuracy are the governing factors in making a choice of method. Many deposits have features that make one method particularly applicable. In some places conditions are such that either the shaft or the drill method may be employed with equally good results; both may be used advantageously. The frozen condition of many of the Alaskan placers makes it possible to use the shaft method in alluvium which, if unfrozen, could be tested by shafts only at a large cost for pumping and timbering.

Where shallow, narrow creek beds are to be prospected it is often good practice to make open cuts clear across the bed, or far enough to delimit the pay streak. Such creeks generally have extremely irregular pay streaks, and cuts of this character would determine the distribution of gold content with thoroughness. Work like this may be costly, but the compensating advantages often justify it.

In a shallow placer less than 10 feet deep and containing no water, or so little water that it can be easily bailed, prospecting can generally be more cheaply and rapidly done with shafts or open cuts than with drill holes sunk with a steam churn drill. Material can be thrown out of a shaft 10 feet deep and no timbering is ordinarily required if the shaft is kept free of water during the sinking. Only one man per shaft is required if there is only a small amount of bailing and if the gravel is unfrozen and easily broken down. At the wages prevailing in 1907 in the Yukon and on Seward Peninsula, 5 feet or more can be sunk per day at a cost of about $1 per foot. Under such conditions the steam churn drill is at a disadvantage, for much time may be consumed in frequent moving from hole to hole. This is particularly true if the surface is so rough or marshy as to make moving difficult. The hand drill, being mobile, can be used advantageously in such shallow gravels, where it can generally drill 25 to 40 feet or more per day, at a cost of about $1 to $2 per foot.

If the alluvium to be tested has a depth of about 25 feet and is so wet as to require a steam pump drill methods are more applicable than shafts. Such unfrozen gravel is generally loose or becomes loose on exposure to the air or by reason of water running into the shaft.

Shaft sinking will be slow and costly, as close timbering and breast boarding or sheet piling may be necessary. Samples taken under such conditions are likely to be inaccurate, for running ground may enter the shaft. The fact that the material from the shaft is shoveled under water, possibly from a rough bed rock or from a soft bed rock which may become sticky by reason of the man puddling it as he works, also introduces inaccuracies. Such conditions are not exceptional; on the contrary, they are generally encountered in prospecting the loose, low-lying gravels of stream beds. When greater depths are attempted in such ground, the same difficulties are encountered in greater degree; the cost of the work may be prohibitive and the samples so unreliable as to be worthless. Under such conditions the churn drill method is preferable. The circumstances that cause slow and costly progress and inaccurate sampling with shafts have no bad effect on steam or hand churn drills. In general, where the gravel is dry, as accurate or more accurate sampling can be done with shafts as with drill holes, but the presence of water in such volume as to require pumping makes drilling preferable.

It is often good practice to use both drill holes and shafts, the idea being to use only enough shafts to allow inspection of the physical character of the gravel, bed rock, etc., and to depend on the drill holes for the determination of the tenor, extent, and thickness of the gravel. If a certain sum is allotted for an examination, this sum will generally, on account of the greater cost of shaft prospecting in wet gravel, pay for the sinking of fewer shafts than drill holes. It is a question whether it is better to have a few large samples or many small samples from a deposit. The peculiar conditions of the alluvium under consideration must therefore be the determining factor.

The irregularity of gold distribution in the alluvium of Alaska makes careful prospecting necessary in order to determine the limits of the pay streaks. Many samples may thus be needed. As a general rule, drill holes are better suited to this work, for they can ordinarily be sunk more rapidly and more cheaply.

Where bench gravel is to be tested, cuts can be easily made. Vertical sampling is thus done, and this method has been used with good results. It is assumed that gravel in the same stratum or at the same perpendicular height above bed rock has the same general tenor and characteristics.

Prospecting has so far in this paper been treated as the obtaining of samples merely. Sometimes it may be conducted as a working test. This is particularly applicable where there is an available water supply. Thus cuts may be ground sluiced through bench gravel and considerable amounts of material washed. Such cuts also permit subsequent sampling of the gravel section to good advantage. Inasmuch as this is a working test, data relative to operating cost may thus also be obtained.

A governing factor in the choice of the prospecting method is the kind of information that is required. Thus in testing alluvium thought suitable for hydraulicking, information concerning the section of gravel from grass roots to bed rock is desired, and generally this can best be obtained by sinking shafts or drill holes. In testing alluvium for drift mining little information is required in regard to any part of the gravel section except that adjacent to bed rock. Openings that follow this lower stratum will, of course, give a maximum of information with a minimum of excavation.

HYDRAULIC MINING.

Hydraulic mining consists in excavating, transporting, and sluicing gold-bearing material and disposing of the tailings by water power. The deposit must be so situated not only that abundant water is obtainable under pressure, but that ample grade for boxes and ground for dumping tailings is procurable. Topography like that of the Sierra Nevada of California and that of the Alaskan coast region is favorable to hydraulic mining. The water supply is not large in most of the great placer districts of Alaska, and ditches must generally be built for considerable distances and over extremely unfavorable ditching ground. Good reservoir sites are few, and dams are difficult and costly of installation and maintenance.

Any installation of mining equipment on a large scale, involving the expenditure of large sums of money, is much more handicapped by the hostile conditions encountered in Alaska than smaller enterprises. This is particularly true of new camps, where the cost of labor, supplies, and transportation is high. In general, before costly equipment of any sort is installed in Alaska placers, it is well to investigate carefully all methods requiring only cheap equipment which may be applicable to the ground under consideration. Only close prospecting can determine what method is most suitable, and it should therefore be done very carefully. Some mistakes have been made in installing expensive water-supply systems without first determining the volume of the alluvium to be worked. It has been found, after beginning operations, that much less material that could be profitably worked was available than was expected. This smaller amount was insufficient to warrant the installation of the plant. Such disasters are the result of inadequate prospecting.

It should be noted that small hydraulic plants have been successfully used in many places to supplement other mining methods. Even when these could be operated only during a part of the season, they have often been made to pay.

Pumping water for hydraulicking has been done in Alaska and the Klondike by means of steam power, but apparently not with financial success. From 1903 to 1906 the operating cost alone for hydraulicking in this way in the Klondike, where it was done on a large scale, was over 50 cents per cubic yard. Fuel cost $15 per cord at the boilers. Where cheap water power is available, electricity may be generated and transmitted to a pumping plant. Under these conditions mining with water may be done profitably, but few plants of this kind have been installed anywhere and these have not been an unqualified success. The use of a large volume of water under a low head to pump a relatively small volume of water against a relatively high head has been tried in but few places and it does not seem to have been entirely successful. Pumping for hydraulicking, or indeed for any kind of placer mining, is a difficult and costly operation, and particularly so in Alaska.

Hydraulic elevators have been installed in some localities where the topographic features are generally unfavorable to ordinary hydraulicking. Although some of these operations have been successful it seems likely that in several of them a more economical method of utilizing the water might have been used. It is well known that the hydraulic elevator is an extremely wasteful machine. It has an efficiency of only about 10 per cent; that is, it generally requires 10 feet of head to elevate the material 1 foot, and of all the water used about two-thirds goes to run the elevator, the rest being available to break down and transport material to it. It is obvious that where but one-third of all the water used is applied to excavating and transporting material (generally under unfavorable conditions resulting from low banks, flat grades to the elevator, and a lack of bed-rock cuts) only a small duty is attained. A duty of less than 1 cubic yard of material moved per miner's inch per twenty-four hours is not exceptional. Similar material favorably located for hydraulicking is handled in other districts at the rate of about 5 cubic yards per miner's inch per twenty-four hours.

Certain factors are conducive to economical work with the hydraulic elevator. They are, first, a fairly deep bank of gravel, say 18 to 25 feet, for in such places the elevator has to be moved a minimum number of times; second, wash of such size that nearly all will pass through the throat of the elevator without necessitating the breaking of large bowlders; third, abundant water; fourth, a deposit so situated that dump must be obtained artificially; and fifth, a deposit carrying much water which would by another method need to be pumped from the pit.

Unfortunately, where water is abundant, as in the regions of high relief, the bowlders are so large and so numerous that the use of elevators is precluded. Therefore this method of mining usually involves the construction of long ditches and consequently large investments, so that extensive gravel deposits of determined value are necessary to obtain profitable returns. In spite of the obstacles, hydraulic elevators are being used, and the operators report success. In a number of localities they have been applied to the removal of the finer overburden, the auriferous gravels being later shoveled in by hand. This procedure is due probably to the fact that the elevator is more or less mobile; at least it can be moved with more facility than can many other forms of equipment which handle gravels on a large scale. In deep ground a large amount of material can be handled at one setting. In one instance on record 180,000 cubic yards were moved from one setting.

OPEN-CUT MINING.

Open-cut mining on a small scale generally includes a considerable expenditure for hand labor, though modified hydraulic mining of some sort may also be used in conjunction with it. Machinery is also often used in excavating, transporting, and sluicing material. The following list of operations shows the great variation in open-cut practice in the Far North: Shoveling to platforms and then to sluice; shoveling into wheelbarrow, wheeling to bucket, and raising on inclined cableway to sluice; shoveling into buckets and hoisting by derrick to sluice; shoveling into cars and hauling on inclined track to sluice; steam shoveling into skip and hauling on cableway to sluice; steam shoveling into sluice sustained on same car with shovel; steam shoveling into sluice sustained on another car; hand shoveling into a troughed belt and conveying to sluice; excavating by ground sluicing or with water under pressure from gravity or from a pump, and sluicing to chain of elevator buckets or a dredging pump raising to sluice; steam scraping to sluice; hydraulicking to hydraulic elevator and raising to sluice.

It is obvious that all these methods can not be described here, nor can their merits and faults be considered. Attention will be called to certain conditions which make some of these methods unsuitable for some localities. Thus steam shovels are not well adapted to mining frozen ground when steam thawing is necessary. The use of belt conveyors or bucket elevators or dredging pumps for transporting material in mining shallow frozen gravel is generally bad practice, because they are heavy to move and costly. In general, in Alaska bulky and heavy machinery should be avoided so far as possible. In the opinion of the writer, as a general rule the steam scraper is the best machine for use in excavating shallow frozen alluvium and where steam power must be used. This conclusion coincides with the statement made by Purington in 1905.[a] Where water power is available, it can be used for scraping.

The inclined cableway and derrick are generally the best machines to transport material to the sluices. Any device that is difficult to move is unsuited for such work, because there is constant need of keeping the means of transportation abreast of the advancing excavation. There is some difficulty in moving mechanical lifts, and for this reason they are not kept near the excavations and there is consequently a loss of time and power. The factor of mobility is an all-important one in placer mining; any mechanism that is not easily mobile must have great compensating advantages to make its use advantageous. Too much emphasis can not be laid on this point.

DREDGING.

GENERAL CONDITIONS.

The success of dredging in California during the last decade has resulted in a widespread tendency to apply this method in a rather unthinking way. Probably 100 dredging machines of various kinds, including those intended for Nome beach mining and not all of the floating type, have been installed in Alaska and all but a few have been failures. This emphasizes most forcibly the prime importance of proper prospecting before installing dredges. It is not the object of this paper to treat gold dredging in detail, but some of the conditions peculiar to Alaska affecting such work will be discussed.

The factors that influence the actual operation of a dredge can be divided into two groups—those intrinsic and those extrinsic to the deposit. Both of these groups influence working cost, and any prospecting to be comprehensive must include consideration of them.

The principal intrinsic factors are: Degree of induration of the gravel; distribution and character of bowlders, clay, and buried timber;[b] occurrence and character of bed rock; average depth to bed rock; average depth to ground water; superficial conditions; average distribution of values and peculiarities of metallic content; by-products, such as platinum; distribution and character of frost, both permanent and seasonal.

The extrinsic conditions are climate, water supply, power possibilities and fuel, labor, cost of supplies and transportation, and installation cost.

Transportation to Alaskan placer fields, which naturally affects operating cost in a great degree, is generally difficult and costly. Climatic conditions are in the main unfavorable. The working season is seldom over 125 days a year. Water supply, for power, is commonly insufficient. Fuel is usually scare and costly. Installation cost is so high that a dredging plant in most parts of Alaska will cost about twice as much as a similar plant in the States. Ground frost (see pp. 55–56) is a prime factor affecting dredging in most parts of Alaska.

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[a] Purington, C. W., Methods and costs of gravel and placer mining in Alaska: Bull. U. S. Geol. Survey No. 263, 1905, pp. 63–65.

[b] Buried timber is not common in Alaska. In the gravel of a bench on a tributary of Kougarok River a log estimated to be 80 feet long was found.

To dredge successfully there must be a sufficient volume of auriferous alluvium, and how great this should be is not easy to state. The life of a dredge is about ten years, so there should be at least enough ground to last that length of time. Generally, the richer the alluvium the less bulk is required. The large dredges, with buckets of 10 to 16 cubic feet capacity, handle over 6,000 cubic yards per day; the small ones, with buckets holding 3 to 5 cubic feet, handle 250 to 1,500 cubic yards per day. Thus in dredging alluvium 30 feet deep the large dredges dig about 3 acres per month and the small dredges from one-sixth to 1 acre per month. The ratio of gold content to the volume of the deposit under consideration must be accurately determined.

The capacity of the dredges should be determined by the character of the ground. It is not good policy to build very large dredges for the Far North, partly on account of the difficulty of transporting heavy pieces; on the other hand, dredges that are too small have such low capacity and such high operating cost that they are not profitable.

DREDGING IN FROZEN GROUND.

There are millions of cubic yards of auriferous alluvium in Alaska that could be very profitably worked were it unfrozen, or were it possible to thaw it cheaply. The principal problem in dredging deposits of this type is that of thawing. At present not only is the problem unsolved, but the chances of an early solution are not encouraging. Dredging can now be carried on in frozen ground only where a very high gold content will warrant the cost for steam thawing.

Frozen ground is very much like concrete in hardness. It is not mechanically impossible to excavate it, but the wear and tear and breakage are so great and the capacity of machines working it is so small that such work can not be done economically. Even were it practicable to excavate frozen auriferous alluvium, it would still be impossible to extract its metallic content without first thawing it to disengage the gold. It can be blasted, but it immediately reunites along the lines of fracture by regelation where there is contact between the fragments. Blasting with shallow holes is often done and with moderate success, for then the broken material may be so shattered as to allow air spaces, so that it can not freeze again by regelation. Frozen ground of homogeneous structure, like some rock, breaks badly in blasting. A vertical blast hole will often break only a conical mass, the apex being at the bottom of the hole. Blasting frozen ground is therefore very costly.

In 1903 an attempt was made in the Klondike to blast frozen alluvium preliminary to dredging. Drill holes were put down with a steam churn drill to bed rock, a depth of about 15 feet, and blasting powder containing 40 per cent of nitroglycerin was used. It was hoped that, after blasting, water would run into the fractures and thus induce thawing, but it was found that the fractured mass reunited by regelation, and thawing had to be done by steam. Frozen alluvium above the present water level contains a smaller percentage of ice and thaws much more rapidly than that below the present water level. Seasonal thawing has been observed by the writer in well-drained bench gravel to a depth of more than 20 feet. Thawing progresses very slowly below water level, for the temperature of the ground water is generally only little above the freezing point.

Thawing ground for dredging has been tried in two ways—(1) by the use of steam, or (2) by stripping the nonconducting surface layer of soil and moss, etc., with mechanical or hydraulic methods and thawing by exposure to the sun and air. Attempts are being made to evolve an electrical thawer, but it has not been used on a commercial scale.

Steam thawing for dredging is not as simple as when drift gravel is attacked. It generally involves sinking the steam points 15 feet or more in order to reach bed rock. This is difficult, for if a steam point strikes a large, hard bowlder, it will be deflected into the ground that a neighboring point is expected to thaw, while its own ground will be left frozen and thus interfere with subsequent dredging. It is impossible to drive steam points to depths much greater than 5 to 8 feet in gravel containing hard round bowlders. To thaw such gravel with steam it would first be necessary to drill a hole before the point could be used, and this would probably make the cost prohibitive.

Steam thawing for a dredge in the Klondike, operating in ground previously worked by drifting or open cutting, is estimated to have cost 25 to 40 cents per cubic yard. This ground, as a result of the previous working, was irregularly frozen, parts of it requiring little or no thawing. Great difficulty was experienced where old open cuts had been partly filled with "muck," which when frozen yields very slowly to a steam thawer. The cost of steam thawing dredging ground in Alaska will not generally be much if any below these figures.

Thawing by stripping and exposure to the air has been successfully done in some places, but so far as known to the writer the attempts to prepare dredging ground in this way are yet chiefly in the experimental stage. Where shallow gravels are so located as to drain while the interstitial ice melts, ground can be thawed in this way. It is evident that this method is best adapted to thawing gravel located above water level. In places where there is abundant water and sufficient grade the muck and moss can be stripped for less than 10 cents per cubic yard, but where the grade is low the overburden generally can not be removed so cheaply.

Plans are under way for exploiting the tundra gravels lying between the sea and the hills near Nome by hydraulic stripping and by exposure to the sun and air. It is thought that progressive thawing will continue and that after several years the total gravel section, in places more than 100 feet deep, will be thawed. The plan outlined is as follows: The moss and soil will be stripped as far down as convenient by ground sluicing and the underlying material will be exposed to the sun and air and allowed to thaw until just before the freeze-up, when the ground will be flooded to a depth of several feet. When the freeze-up comes the ground will be covered with ice, which it is assumed will prevent more than slight superficial freezing of the material below it. The ice will melt early next season, and then the gravel will thaw again, to a greater depth. This will be continued for several years until the thawing has reached bed rock. There are many undetermined factors involved in this plan, but we may disregard all except two. It has not been definitely established that the ground thawed in summer will remain thawed during the winter, even if covered with a blanket of nonconducting ice. It has been observed in some localities that ground thawed in summer, either by steam or otherwise, freezes again even during the summer if at a considerable depth and away from the influence of sun and air. This seems to be caused by the adjacent frozen ground abstracting heat to such a degree as to freeze the thawed mass. It would appear, therefore, that the temperature of some of the frozen ground is somewhat below 32° F., though there are no accurate observations on this point. Another important factor in this mode of thawing is the physical character of the material. If it is gravel or sand, it will thaw to considerable depth when the surface coating is stripped. If, however, loose material is interbedded with impervious clay or humus—a condition that exists in some places—these may have to be stripped before the heat can reach the underlying loose material.

DREDGING IN UNFROZEN GROUND.

The capacity of the Alaskan dredges operating in unfrozen ground is about the same as that of similar dredges working in the temperate zone. The material, when unfrozen, is generally more favorable to rapid handling than that dredged in California and Montana. The dredges may be thoroughly overhauled each winter and therefore they can run through the entire working season without extensive repairs, and there is consequently a smaller amount of lost time. Some instructive data bearing on this point may be given. Two dredges of exactly the same capacity, design, and construction have been working for several years—one in the indurated gravel at Oroville, Cal., the other in unfrozen gravel in the Klondike. At Oroville the working season extends throughout the year; in the Klondike it covers one hundred and fifty days. The Oroville dredge has averaged about 2,900 cubic yards per day; the Klondike dredge about 3,400 cubic yards.

COST OF DREDGING.

On Seward Peninsula, with a well-designed steam dredge and with coal at $20 per ton, the cost of dredging is probably about 20 cents per cubic yard. This cost is for gravels which are fine, generally unfrozen, and of medium depth, lying upon a generally favorable bed rock. Gravel of similar character is dredged in more accessible regions in the States for less than 8 cents per cubic yard, but for most of Seward Peninsula the figure given above will probably be little, if any, reduced under present conditions.

Dredging costs more in the interior than on the coast on account of the greater expense of transportation, etc. A dredge with buckets of 7.5 cubic feet capacity is working in generally unfrozen and favorable ground in the Klondike. Wood costing about $8 per cord is burned and a steam turbine is used to generate electricity for the dredge. The operation is said to cost about 12 cents per cubic yard, but it is likely that even with these favorable conditions the real cost is little, if any, under 20 cents per cubic yard.

Dredging cost in frozen ground is increased by thawing cost, which may range from about 25 cents to 40 cents or more per cubic yard; it may even be as it has been in certain places in the Klondike, more than 80 cents per cubic yard. It is not likely that dredging frozen ground requiring steam thawing can ever be conducted for less than 50 cents per cubic yard unless a new means of thawing shall be evolved. This means that inasmuch as it is exceptional to find extensive deposits of alluvium of such high tenor, frozen ground in general can not be dredged profitably.

DEPTH OF DREDGING.

Dredging can be prosecuted to as great depth in Alaska as elsewhere. In California excavation is now being carried to a depth of about 65 feet below the water level of the pond in which the dredge is floating. This is the greatest depth yet attained, but it is by no means the limit, and it can not be predicted what the mechanical limit really is. The greatest depth yet dredged in the Far North is about 35 feet.

Shallow gravel can be dredged if it can be flooded to a depth sufficient to permit floating the dredge over the bed rock. Such thin gravels may be impracticable to dredge, for the dredge must move ahead very frequently and it is difficult to fill the buckets constantly. Many deposits of this nature may be more advantageously worked by other methods. A large area of such material would be needed for dredging, as if the material were, say, 2 feet deep, and if it were dug at the rate of 3,000 cubic yards per day, about 1 acre a day would be exhausted. It may be said, however, that dredges to operate in shallow gravel need but short ladders and stackers, and thus small hulls are sufficient. Such dredges are cheaper to construct and operate than those that mine to a great depth.

DRIFT MINING.

Drift mining will continue to have a wide application in the northern placer fields. It generally requires only inexpensive equipment and it is therefore well suited to the inaccessible parts of Alaska. In this northern field there is generally a concentration of gold content near, on, and in the bed rock, so that a large percentage of the total gold tenor in gravel can be extracted by drifting. As a matter of fact other methods have been applied where drifting should have been undertaken. For instance, if the ground is 21 feet deep, and if 95 per cent of the pay is concentrated in the lower 2 feet of the gravel and the upper 2 feet of bed rock, it will be cheaper to drift than to handle the ground by a hydraulic elevator, on the assumption that the cost of handling gravel with an elevator is $1 a cubic yard and that of drifting is $4 a cubic yard. With the elevator each square yard of bed rock cleaned would cost in ground of this depth more than $7. With drifting the cost would be less than $4 per square yard of bed rock. The gain by the elevator method of the 5 per cent of the entire tenor which is carried in the upper 19 feet would generally not make up for the difference in cost.

There is nothing spectacular in drift mining and it has no such seemingly powerful fascination as is presented by the mighty streams from the hydraulic nozzle, excavating and caving gravel banks; but a practical man can see that drift mining should have a much wider application than at present. It is reported by Mr. Prindle that under present conditions in Fairbanks[a] ground with gold content less than $2.75 per cubic yard can not be mined at a profit. This is where the drifts are about 6 feet high. It is almost impossible to arrive at any exact figures, because very few operators have any definite knowledge of the cost of their work. As a matter of fact, the miners in the Fairbanks district have been so accustomed to mining very rich ground that they are inclined to disregard the lower-grade gravels, some of which could in some cases be profitably mined even with the present cost of labor, supplies, etc.

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[a] At Fairbanks over half of the operations consist of drifting in alluvium 50 to 200 feet deep.

The cost above given compares very favorably with that of drift mining in some parts of California, which has been more than $3 per cubic yard. The maintenance of long tunnels in swelling ground, the use of much timber, extensive pumping, long haulage, hardness of gravel, etc., are some of the many reasons for costly operation in parts of California. It is interesting to note the operating cost of mining gravel at the Hidden Treasure mine, Placer County, Cal., where economical work has been done. The gravel is of the "white channel" type, which is similar, not only in color but in other features, such as hardness, to that of the "white channel" of the Klondike. It is generally worked without blasting and the breasts must be closely timbered. The working tunnel is about 2 miles long and gravel is trammed out by electric locomotives operated by power generated by water from the mine tunnels. The cost per ton of mining with electric haulage is about 84 cents, haulage 5 cents, total 89 cents. When animal traction was used the mining cost was 90 cents and the haulage cost 12.6 cents, a total per ton of $1.026. At times over 15 men were employed in the upkeep of the main tunnel, which is for a part of its length in swelling bed rock.

The effect of frozen ground on the cost of drift mining has been indicated on page 55. It is interesting to note that there are extensive deposits in the Tanana region that could not be mined by drifting were they unfrozen, for then the expense of pumping and timbering would be excessive. Neither could many of these deposits be mined by dredging, as the depths are in places too great and there is usually insufficient gold in the upper gravel to pay for dredging. The cost for timber varies greatly and no average can be given. Seward Peninsula is generally treeless. Timber is imported from Puget Sound at a heavy cost; therefore near Nome it is usual to abandon mining when unfrozen material is encountered in drifting. At many places in the interior, also, mine timber is scarce and costly.

LODE MINING IN SOUTHEASTERN ALASKA, 1907.

By Charles W. Wright.

INTRODUCTION.

The mining industry in southeastern Alaska has not advanced materially during the last year, and the total metal production was not as great as that for 1906. This slight decrease is attributed to unfavorable conditions of labor and transportation and the fall in the market value of copper. These adverse factors have affected the mining interests not only of southeastern Alaska, but likewise of many of the Western States.

Before considering the ore bodies and mines under development in detail, a brief discussion is given of the general geology of southeastern Alaska and the distribution of the ore deposits within this area. To present the matter more clearly a map (Pl. II) has been compiled showing the general distribution of the rock formations and more particularly the larger areas of intrusive rocks. The scale of this map is about 30 miles to the inch and on it the positions of the mines and prospects are indicated. As the mapping was confined largely to the vicinity of salt water, the geology of many of the inland areas has been inferred and does not represent actual observation.

A striking feature shown on the map is the proximity of the ore bodies to the intrusive areas, thus suggesting a genetic relationship of the mineral deposits of the igneous rocks. The greater occurrence of gold in the northern districts and of copper to the south in the Ketchikan district is also noteworthy.

Detailed statements of the known geologic facts and the character of the ore deposits of the principal mining districts in southeastern Alaska are set forth in the reports on the Juneau gold belt[a] and on the Ketchikan and Wrangell mining districts.[b]

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[a] Spencer, A. C., The Juneau gold belt: Bull. U. S. Geol. Survey No. 287, 1906.

[b] Brooks, A. H., The Ketchikan mining district: Prof. Paper U. S. Geol. Survey No. 1, 1902. Wright, F. E. and C. W., The Ketchikan and Wrangell districts: Bull. U. S. Geol. Survey No. 347, 1908.

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U. S. GEOLOGICAL SURVEY

The investigations of the United States Geological Survey in southeastern Alaska during 1907 were confined to a study of the copper deposits on Kasaan Peninsula, and the preliminary results of this work are set forth in a separate paper in this bulletin. At the close of these investigations the writer visited the principal mines in the Ketchikan and Juneau districts, and notes on their progress during the last year are contained in this report.

An outline of the general geology of southeastern Alaska, with a geologic map, has been presented each year in the Progress Report,[a] but as each successive year reveals new facts it seems advisable to republish in the present report a brief sketch of the general geology of the region, and to add the more complete accompanying map, representing the distribution of the rock formations so far as known. Inasmuch as a large portion of the territory still remains unexplored, and as most of the geologic investigations have been of a reconnaissance nature, some of the statements and conclusions in this, as in former reports, may be modified by more detailed studies.

GEOLOGIC SKETCH OF SOUTHEASTERN ALASKA.

The geologic distribution of the rocks along the southeastern coast of Alaska is on a broad scale, and in their strike they follow the general northwest trend of the mountain ranges. The rocks may be divided into two main groups—(1) stratified rocks and (2) intrusive rocks, both having about the same areal extent.

The stratified rocks include those of sedimentary and volcanic origin, which, except the more recently formed rocks, are in general intricately folded and usually show a high degree of metamorphism. As indicated on the map, these rocks are subdivided according to their age: The Paleozoic, including crystalline limestones, quartzites, schists, phyllites, and greenstone lavas and tuffs; the Mesozoic, including slates, graywackes, conglomerates, some limestones, and andesitic lavas and tuffs; the Tertiary, including sandstones, shales, conglomerates, and rhyolitic lavas and tuffs. The stratigraphic succession of these rock strata is complex, and nearly all the geologic periods, from early Paleozoic to the present, are represented.

The intrusive rocks are made up of a complex of coarse granular rocks, mostly granitic in character. They form the great mass of the Coast Range bordering the mainland and occupy wide areas in the central portions of many of the islands. Their mode of occurrence is at many places directly related to the geologic structures, and the longitudinal axes and lines of contact of these intrusive masses are usually parallel with the strike of the bedded rocks. These intrusive rocks, the most dominant geologic feature of the mainland, have been discussed by Brooks[a] in the report on the Ketchikan district, and by Spencer[a] in the report on the Juneau gold belt; their occurrence in British Columbia, where conditions similar to those along the mainland of Alaska prevail, has been carefully considered by Dawson.[b]

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[a] Wright, F. E. and C. W., Economic developments in southeastern Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 47–68; Lode mining in southeastern Alaska: Bull. No. 284, 1906, pp. 30–53. Wright, C. W., Lode mining in southeastern Alaska: Bull. No. 314, 1907, pp. 47–72.

The Coast Range massif consists of many separate interlocking batholiths intruded at successive epochs but during the same general period of invasion. At the close of this period pegmatite, aplite, and granite porphyry dikes were intruded into the outer portions of the granitic masses and adjacent schists, and contemporaneous with or just subsequent to the intrusion of these dikes the mineral-bearing solutions were introduced. Both dikes and mineral deposits were probably derived from the same igneous magmas, which were the source of the granitic intrusives near which the dikes occur. This general invasion is believed to have occurred during early Mesozoic times.

The later intrusive rocks consist of felsite, diabase, and basalt in the form of dikes cutting both the older and younger stratified rocks and the Coast Range intrusives. These apparently have no direct bearing on the ore deposits.

That the different masses of intrusive rocks are not surrounded by similar metamorphic phenomena and that the apparent metamorphism caused by the mainland intrusive belt is quite different from that effected by the smaller intrusive masses on the islands are facts that have been frequently noted. The stratified rocks flanking the Coast Range along the mainland are intensely folded and metamorphosed and were without doubt deeply buried at the time of the granitic invasion. Deep-seated metamorphic processes were already active and had probably altered these rocks to such an extent that the igneous intrusion did not disturb their equilibrium greatly, its chief effect being to accentuate the processes of crystallization already in force rather than to replace them by others.

The occurrence of innumerable pegmatite dikes along the margins of the Coast Range batholiths is a significant indication of the immense quantities of pneumatolytic solutions given off by the invading crystallizing magmas. These magmatic solutions, containing dissolved metallic sulphides as well as silicates and other minerals, penetrated the adjacent schists, where the temperature permitted the deposition of minerals composing the pegmatite dikes, but was evidently too intense for the precipitation of the metal-bearing minerals. Farther away from the granitic intrusion magmatic solutions given off by these igneous masses encountered conditions more favorable to the precipitation of the metallic sulphides, and as a result the principal ore bodies along the mainland are found in the slate and greenstone strata 3 to 10 miles from the contact of the Coast Range intrusive mass.

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[a] Op. cit.

[b] Dawson, G. M., Report on an exploration in the Yukon district and adjacent portions of British Columbia: Geol. Nat. Hist. Survey Canada, vol. 3, pt. 1, 1887–88, pp. 1–277 B.

On the islands the stratified rocks, though much altered, do not show the intense metamorphic character expressed in those of the mainland, and the contact-metamorphic influence of the intrusive masses is therefore in greater evidence. The contact metamorphism is confined in great part to areas within a few thousand feet from the intrusives, the amount of alteration being largely dependent on the distance from the igneous mass and the character of the intruded rock strata. The alteration of slates and quartzites to hornfels, the recrystallization of limestone to marble, and the development of garnet, epidote, wollastonite, scapolite, and other minerals in the rock strata are direct evidences of such metamorphic action.

ORE DEPOSITS.

GENERAL STATEMENT.

The distribution of metallic mineralization in southeastern Alaska is confined to certain rock formations, and in these the mineral deposits occur to some extent along certain zones which have been more or less satisfactorily determined. Because of the rough topography and the dense growth of forest and underbrush, investigations of such belts have necessarily been limited to the vicinity of salt water, where the rock formations and mineral belts are clearly exposed.

Some of the facts that have been set forth in previous reports are the following: (1) The metallic minerals usually occur in the proximity of granitic intrusives; (2) for the most part, the ore bodies were deposited subsequent to the granitic invasion; (3) the rocks of post-Paleozoic age are practically barren of valuable mineral deposits; and (4) the ore deposits are genetically related to the granitic intrusives. From these facts it is evident that the areas occupied by Paleozoic rocks and in proximity to the granitic intrusive masses are the most favorable for the occurrence of ore deposits.

PRINCIPAL CHARACTERISTICS OF ORE DEPOSITS.

Three general types of ore deposits are prominent in southeastern Alaska—vein deposits, lode deposits, and contact-metamorphic deposits. Deposits at variance with these types are the breccia veins in limestone, at Dolomi, and the mineralized diorite at the Treadwell mine, which have been discussed in previous reports.

The vein deposits include any mineral mass or aggregate occupying a fissure or fracture in the rocks. In this region they are usually made up of auriferous quartz and calcite, with a small percentage of metallic sulphides, though veins of nearly massive sulphide ore, rich in copper and in some places carrying lead and zinc, are also present. They range from 1 to 10 feet in width and usually crosscut the inclosing rock. Such deposits occur in practically all the older rocks of the district, including the intrusives, but are rarely found in the Mesozoic rocks and have not been observed in the Tertiary sedimentaries or eruptives. These facts and a lack of evidence suggesting mineral deposition previous to the invasion of the intrusive masses indicate the intrusive rocks as the probable source of the mineral solutions from which these veins were deposited.

The lode deposits consist of bands of schistose rock, in places including dike rocks, which are intersected by veinlets of quartz and calcite and impregnated with metallic sulphides. These lodes range from 5 to 50 feet in width and are usually of great persistence both in length and depth. Gold is the principal metal in them and is confined largely to the quartz and calcite veinlets. The lateral limits of the lode deposits are in few places sharply marked, and in the inclosing country rock the mineralized portion gradually changes to the unmineralized rock. Such deposits are prominent in the Juneau district, where they occur in the slates and greenstones, and they are also present on Gravina Island in the Ketchikan district.

The term contact-metamorphic deposits is here restricted to those mineral bodies which have been formed by contact-metamorphic agencies and which carry the minerals characteristic of such action. Such deposits occur mostly in limestone or calcareous rocks, usually within 1,000 feet of the intrusive bodies. The mineral solutions given off from the igneous masses previous to their entire solidification penetrated the adjacent limestone and quartzite beds and ascended along the intrusive contacts, dissolving channels, though in many places taking advantage of preexisting fissures in both the intrusive and intruded rocks. During their ascent the thermic and other conditions of the aqueous solutions changed and their mineral contents were precipitated, gradually filling the channels and fissures. As carbonate of lime is a ready precipitant of these mineral solutions, the largest ore masses were usually formed at points where limestone is the intruded rock. The contact-metamorphic deposits are composed of a massive garnet and epidote gangue in which chalcopyrite, pyrite, pyrrhotite, and magnetite occur in disseminated grains and masses. Such deposits are largely developed at several localities on Prince of Wales Island. They range from 25 to 200 feet in lateral dimensions and are confined to the contact aureoles of the larger intrusive masses.

DISTRIBUTION OF MINERAL DEPOSITS ALONG THE MAINLAND BELT.

Within the mainland belt, which includes the adjacent islands, mineralization is scattered both in the granitic intrusives and in the adjacent stratified rocks. Along certain lines or zones and in certain rock formations this mineralization is greater than at other points, and such zones are termed "mineral zones." As noted above, the highly metamorphosed schists adjacent to the Coast Range intrusive belt are less favorable for the occurrence of valuable ore deposits than the slates and greenstones which border the coastwise channels.

The most extensive and productive zone is the Juneau gold belt, which has been irregularly traced along the mainland from Windham Bay to a point 10 miles north of Berners Bay, where it enters Lynn Canal. It has a total length of 120 miles and a width of less than 10 miles. In this zone gold is the dominant metal present and occurs in varying amounts disseminated with sulphide minerals in bands of schistose rock 10 to 60 feet wide; in altered diorite dikes, where it is associated with stringers of quartz; and in quartz veins, 1 to 10 feet wide, cutting either the intrusive or schistose country rock. These ore bodies within this zone are discussed at length by A. C. Spencer in his report on the Juneau gold belt.[a]

In the Wrangell district the concentration of metallic minerals along definite zones has apparently not taken place, though a number of mineral prospects have been found, namely, in Thomas and Le Conte bays, along Bradfield Canal, and in Groundhog and Glacier basins. At the last two localities silver and lead ores, occurring in quartz veins inclosed in the crystalline schists, are prominent; at the others gold is the dominant metal.

Within the mainland belt of the Ketchikan district, which includes Revillagigedo Island, quartz veins and mineralized schist bands are found locally, but they are too widely separated to permit the definition of a mineral zone like that in the Juneau district. The slates and greenstones contain the largest percentage of metallic minerals, and in them deposits have been developed on Gravina Island, along the west shore of Revillagigedo Island, and on Cleveland Peninsula. In the slates and schist nearer the Coast Range intrusives vein deposits have been found at the head of Thorne Arm and in George Inlet. For the most part the deposits in the mainland portion of the Ketchikan district consist of simple veins in fissures and lode deposits of complex composition, containing only moderate values in gold.

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[a] Op. cit.

DISTRIBUTION OF MINERAL DEPOSITS ON THE LARGER ISLANDS.

On the larger islands of southeastern Alaska the regularity of the rock structure and the continuity of the formations is locally interrupted by intrusive areas of granitic rocks and wide channels separating the islands. For this reason it is not possible to trace for any great distance mineral zones comparable with those along the mainland. The occurrence of the deposits on each island differs somewhat, and the islands are described separately in this paper. In general, the ore bodies appear to be closely connected with the intrusive rock masses, many of them lying at or near the contacts of the intrusives.

On Admiralty Island valuable mineral deposits have been found at two localities. The central and southern portions of the island are occupied by Tertiary rocks comprising sandstones, conglomerates, lavas, and tuffs, in which no mineralization of importance occurs. The northern portion of the island is made up of Paleozoic beds which are metamorphosed and locally intruded by granitic masses. The areas of intrusive rocks, so far as known, are small, and the occurrence of valuable mineral deposits is relatively rare. A poorly defined mineral zone starts at a point just north of Windfall Harbor, on the west side of Seymour Canal, and is traceable northwestward to Funter Bay. It is about 30 miles long and 2 miles wide and includes several prospects but no producing mines. Other prospects are located on the west coast of the island a few miles north of Kootznahoo Inlet.

The two seaward islands, Baranof and Chichagof, which constitute the Sitka mining district, are made up of a central core of intrusive rock. These intrusives invade Paleozoic limestones, quartzites, and schists, which are overlain by greenstones and graywackes of late Paleozoic or early Mesozoic age. A poorly defined mineral zone occurs in the metamorphic schists flanking the west side of the intrusive belt, starting at Red Bluff Bay, on the east side of Baranof Island, and extending northwestward, including the prospects at the head of Silver Bay and in the vicinity of Cape Edward, north of which it enters the ocean. Auriferous vein deposits are the principal type of ore body in this mineral zone. Another zone of mineral-bearing schists was noted along the east side of this intrusive belt, extending from Hooniah Sound to Lisianski Strait and northwestward on the mainland from Cape Spencer to Lituya Bay, where it flanks the St. Elias Range. Only a few prospects in the vicinity of Rodman Bay and at the head of Hooniah Sound have thus far been located in this mineral zone.

Kupreanof and Kuiu islands may be described together. They differ from the other islands in their lack of intrusive areas and in having relatively low topographic relief. Their central and southern portions are covered by basaltic lavas and tuffs overlying the Tertiary coal-bearing formations exposed in Hamilton Bay, all of which are barren of minerals. Triassic beds appear in Hamilton Bay and overlie Carboniferous limestones. A succession of slates and greenstones, probably of Carboniferous age, occupies the eastern portion of Kupreanof Island, and in these rocks mineral deposits carrying both gold and copper ores occur and have been developed at several points along Duncan Canal and Wrangell Narrows. Along the western and southern shores of Kuiu Island is a great thickness of quartzites and graywackes, which underlie beds of Silurian limestone exposed at Meade Point on the north end of the island. In these rocks no important mineral deposits have been found.

The distribution of mineralization on Prince of Wales Island, like that on the other islands, is dependent on the intrusive areas. Here the direct relations of the ore bodies to the intrusive rocks are more evident because the ores occur in many places along the contacts of the intrusive and intruded rocks. The intrusive areas are irregular masses and are most prominent along the eastern and southern portions of the island. Limestones, greenstones, and phyllites are the principal stratified rocks. Copper is the dominant metal in many of the deposits. It is present within the contact aureoles of the intrusive masses, as on Kasaan Peninsula and in the vicinity of Hetta Inlet, and occurs as lenticular masses or veins along shear zones in a greenstone schist country rock, as at Niblack and Copper City. Gold accompanies the copper deposits as an accessory constituent and is found in vein deposits inclosed in limestones at Dolomi and in black slates or phyllites in the vicinity of Hollis.

GOLD MINES AND PROSPECTS.

GENERAL STATEMENT.

The gold mines of southeastern Alaska are few and scattered and only a small number of the many gold prospects have been developed to the producing stage. Although this metal is widely distributed in all the older rock formations in the form of both veins and lodes, it is rarely found in deposits sufficient in size and grade to constitute valuable ore bodies, and those localities where the ore bodies are being mined are necessarily situated but a short distance from tidewater, where transportation facilities and water power are available. The ore produced from these mines is for the most part free milling—that is, an ore from which the greater percentage of the gold content can be extracted by amalgamation. It is therefore most advantageously treated in a stamp mill by amalgamation and concentration, and the concentrates alone should be shipped to the smelter for treatment. However, in certain instances, where a siliceous ore is in demand, the gold ore has been sold direct to the smelter. In general the vein deposits contain the largest values per ton, but the lode ores, though lower in grade, are present in greater quantity. Deposits of both types are being mined with profit.

GOLD PRODUCTION.

The 1906 production from the gold mines in southeastern Alaska is given in the following table:

Production of the gold mines in southeastern Alaska, 1906.

Ore mined.	Gold.		Silver.		Average per ton.			
					Gold.		Silver.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
Tons. 1,399,456	*Ounces.* 159,634.68	$3,298,943	*Ounces.* 23,532	$15,772	*Ounces.* 0.115	$2.38	*Ounces.* 0.017	$0.011

The production for 1907 has not been as large as that for 1906, though the decrease is slight. The exact figures can not now be given, as the statistics are not complete. To obtain the total gold production of southeastern Alaska, that from the copper mines, which amounted to $62,831 in 1906, should be added to the above figures. It is to be noted that nine-tenths of the gold output was from the Treadwell group of mines on Douglas Island.

JUNEAU MINING DISTRICT.

Operations have been in progress at most of the mines within the Juneau district, though there are few mining developments to be noted. Prospecting has advanced along the gold belt to the north of Eagle River, and at the head of Gold Creek, where auriferous quartz veins are being explored. On Douglas Island and to the south of Juneau no new finds are reported. The production for 1907 from these mines was somewhat less than it was for 1906.

MINES ON DOUGLAS ISLAND.

The Treadwell group of mines on Douglas Island, which is the principal gold producer in southeastern Alaska, has been fully discussed by Spencer[a] and Kinzie,[b] and only a brief statement of the recent developments will be made here. An interesting improvement at this group of mines is the introduction of the use of oil in place of coal for steam-producing purposes. This economizes both in labor and the initial cost of fuel, and has greatly reduced the costs for power. The available water power has also been increased by enlarging the dam at the head of Fish Creek and building a small dam on Bullion Creek.

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[a] Op. cit.

[b] Kinzie, R. A., The Treadwell group of mines, Alaska: Trans. Am. Inst. Min. Eng., ol. 34, 1904, pp. 334-386.

At the Alaska Treadwell mine the principal developments were advanced on the 1,450-foot, 1,250-foot, and 1,050-foot levels, and on these the ore body has been opened for a width of 450 feet. The shaft has been extended to the 1,650-foot level. The ore extracted was derived principally from the 750-foot and 900-foot levels. On the adjoining property, the Seven Hundred Foot claim, the 990-foot level was extended to connect with the 1,050-foot level of the Treadwell mine, and developments were advanced on the 880-foot and 990-foot levels. The ore mined is sent to the mill at the Mexican mine for treatment, though the old 100-stamp mill on the Seven Hundred Foot claim is being remodeled and will be used to treat the ore from this claim in the near future.

At the Mexican mine development work has consisted essentially in the opening up of stopes from the 550-foot and 770-foot levels on the hanging-wall ore body. On the 880-foot and 990-foot levels stopes have been extended into the main ore body. The 1,100-foot level is being extended to the east and west and will undercut the workings on the Seven Hundred Foot claim.

The Ready Bullion mine workings, which extend well out under Gastineau Channel, have attained a depth of 1,650 feet, the principal developments having been extended on the 1,500-foot level. The character of the ore body was not found to change materially at this depth. Most of the ore mined was derived from the 1,300-foot, 1,200-foot, and 1,000-foot levels.

The other properties on Douglas Island have been idle during the year.

GOLD CREEK MINES.

The development of the mines along Gold Creek did not advance to the extent anticipated in 1907, and has been hindered considerably by litigation difficulties. Plans have been made for large improvements during 1908.

The mines, the Ebner, the Alaska Juneau, and the Perseverance, are developing low-grade lode deposits within a mineral belt 800 feet wide, extending from the west side of Gold Creek southeastward over the divide to Sheep Creek, a distance of 6 miles. The lodes, usually from 10 to 50 feet wide, are the richer portions of this mineral belt, within which the black slates and dike rocks are intersected by numerous quartz stringers and the rock itself is impregnated with sulphide minerals.

The Ebner mine was in continuous operation the first half of the year, and during this period the 15-stamp mill was running most of the time. In the second half of the year work was suspended.

Operations at the Alaska Juneau mine were renewed the first week in June and continued till the first of November. The weather conditions during the winter months are unfavorable to the open-pit method of mining employed at this property. The 30-stamp mill was in continuous operation during this period. A tunnel and raise was extended to undercut the west end of the upper pit, and a hoist and tramway were installed at lower pit No. 2, from which one-half of the ore milled was derived.

At the Perseverance mine underground developments were in progress throughout the year. The ore was stoped largely from the main raise extending from the adit tunnel to the surface, a distance of 920 feet. The ore body, which at this point is from 60 to 80 feet in width, has been developed by a drift 1,100 feet in length, and from this drift at intervals of 20 feet chutes are being extended to an intermediate drift 25 feet above. From this intermediate level stoping of the ore has begun over a length of 150 feet to each side of the raise. A stamp mill below the mine began operations with 30 stamps on June 1 and two months later 50 stamps were put into use. In November 100 stamps were ready for use, but the weather necessitated the discontinuance of milling operations for the year. With the completion of the proposed improvements for water-supply and power purposes, it will be possible to operate the 100-stamp mill during the greater portion of the year. Small developments were made by the Alaska Perseverance Mining Company at the adjoining Sheep Creek mine.

Placer mining in Silverbow Basin was advanced by the Silver Bow Hydraulic Company from May 25 to July 15. A hydraulic elevator was then installed, and was operated until August 7, when increased rainfall caused a flooding of Icy Gulch and Gold Creek, which filled the placer excavations and caused a suspension of operations. No further work was done at this locality.

MINES NORTH OF JUNEAU.

At only a few of the mines and prospects north of Juneau have developments been in progress throughout the year. The Salmon Creek, McGinnis Creek, and Montana Basin prospects have been idle, except for the completion of assessment work. At Windfall Creek no attempt was made to operate the placer deposits, and only a small amount of prospecting was done on the quartz veins at the head of the creek. The Peterson Creek prospects were developed in a small way throughout the year by the owner, and the ore mined was treated in a 2-stamp mill on the property.

At the Eagle River mine developments were vigorously advanced during the year in search of the main vein, which is displaced by a fault. The workings now show both the character and the extent of this comparatively wide zone of faulting, and extensive developments are being advanced on this vein deposit at points farther into the mountain beyond the folded zone. The displacement caused by this fault amounts to a lateral throw of 400 feet and a downward movement of 200 feet. The fault plane has a general northeasterly strike and a dip of 30° SE. The strike of the ore body is to the northwest and the dip to the northeast. The vein ranges from 1 to 15 feet in width. Developments are also being advanced on the hanging-wall vein 150 feet northwest of the main vein and parallel to it. This vein ranges from a few inches to 8 feet in width. Similar parallel veins have been prospected by short tunnels at other points on the property. A total of 12,000 feet of drifts, crosscuts, and raises has been opened at the Eagle River mine. The 20-stamp mill on the property has been in continuous operation throughout the year.

Considerable interest has been shown in the prospects to the north of the Eagle River mine, at Yankee Basin, and at the head of Cowee Creek, where auriferous quartz veins are being explored. The Dividend lode was undercut at a depth of 350 feet by a 900-foot tunnel, which is being extended to a length of 1,700 feet, at which distance it is estimated that it will undercut the Cascade vein. The Dividend lode, which is being explored at the tunnel level, is said to have a width of more than 60 feet and to contain gold values. The Cascade is a 6-foot quartz vein developed on the surface by two prospect shafts and open cuts. The Julia, Puzzler, Noonday, and other claims adjoin the above-named prospects and include some promising vein deposits. About 1½ miles northwest of Yankee Basin is the Cottrell-Spalding group of claims, on which a vein is reported to be exposed over a length of 1,500 feet, averaging 2½ feet in width and carrying gold values. A crosscut tunnel 160 feet long undercuts the vein 100 feet in depth. On the Black Chief claim, to the northeast, vein deposits parallel to the Cottrell vein are being explored. Other prospects which have been developed during the year are the Maud S. group, on which an 80-foot tunnel crosscuts a 4½-foot vein 50 feet in depth; the Joyce-Jensen-Johnson group, which is supposed to include the northwestern continuation of the Cottrell vein; the Blue Jay claim, on which a vein deposit is opened by a 25-foot drift tunnel; and the Yankee Boy and Yankee Girl claims, which may be an extension of the Blue Jay vein. On the Gold Standard group, adjacent to Echo Inlet, considerable work was done during the latter part of the year, and favorable results are reported.

In the Berners Bay region the Jualin was the only mine where developments were in progress. This property was operated under a lease, work having begun the first of June and continued until October. During this period the 10-stamp mill was in operation for fifteen weeks. Developments were carried on principally on the 220-foot level, a crosscut being extended for 280 feet from the shaft to undercut the north vein, which at this level was found to be 6 feet wide, and along it 80 feet of drifting was done. The ore mined was taken from the west vein, along which the drift has been carried for 350 feet. Above the 220-foot level most of the ore has been stoped out. Only a few men will be employed during the winter to continue the developments.

The other mines in the Berners Bay region have been idle because of litigation difficulties which still remain unsettled.

MINES SOUTH OF JUNEAU.

Mining progress at the mines and prospects south of Juneau has not been extensive, and at only one locality has there been any gold production. Small developments have taken place during the year on the Bach group of claims at Limestone Inlet, where a quartz vein averaging 2½ feet wide and inclosed in granitic country rock has been exposed over a length of 500 feet.

At Snettisham work was advanced in the Crystal mine from early spring until late in the fall, and a considerable tonnage of ore was treated in the 5-stamp mill on the property. The upper tunnel was connected with the second level by a raise and from the second level a shaft has been started.

At the Holkham Bay group of claims, located on the south side of Endicott Arm, small developments were made during the summer and a right of way for an aerial tramway was cleared from the beach to a point at an elevation of 1,500 feet and 4,500 feet from tidewater. From this point a crosscut tunnel has been started to undercut the vein deposit 400 feet in depth at a distance of 420 feet from its mouth.

No attempt was made to renew operations at the Sumdum mine. Except a small amount of assessment and prospect work, there was no mining activity in the vicinity of Windham Bay.

ADMIRALTY ISLAND.

There has been no noteworthy mining progress at the prospect on Admiralty Island. Small improvements have been made on the properties adjacent to Funter Bay, and assessment work is reported to have been done at the Mammoth group of claims near Young Bay.

SITKA MINING DISTRICT.

The only active mining operations during the year within the Sitka mining district have been at the DeGroff mine, owned by the Chichagof Gold Mining Company. At this mine a 2-stamp mill with a Wilfley concentrator was erected and a steam plant and a 2-drill air compressor installed. The drift along the vein at the upper tunnel level was extended for 260 feet, and at a point 156 feet lower, on a level with the ore bin in the mill, a second tunnel has been started to develop the vein at this depth. The mill began operations the first of September and was run to its full capacity the rest of the year. On the Mills prospects, just above the DeGroff mine, a 300-foot drift tunnel was extended along the vein, and below this a 70-foot drift tunnel, and encouraging results are reported.

The vein and lode deposits adjacent to Silver Bay, on Baranof Island, some of which were extensively developed in former years, have received little attention this year, no work, except assessment work on some of the properties, having been in progress.

WRANGELL MINING DISTRICT.

There has been little progress within the Wrangell district during the last year and no new discoveries are reported. The Olympic Mining Company renewed operations with a small crew of men in May and continued until August, work being done on the Helen S. group of claims. No important developments were accomplished on the gold-copper prospects at the head of Duncan Canal.

KETCHIKAN MINING DISTRICT.

Gold plays but a minor rôle in the mining interests of the Ketchikan district, and its production has been largely from the copper ores, which carry from 50 cents to $2 in gold per ton of ore. In this district gold deposits occur locally, but are too widely separated to permit the definition of a mineral zone. The most general distribution of this metal is in the slates and greenstones bordering Tongass Narrows and extending northward on Cleveland Peninsula, where the gold occurs in lode deposits. On Prince of Wales Island it is found in vein deposits inclosed in limestones, as at Dolomi, and in black slates or phyllites in the vicinity of Hollis.

PRINCE OF WALES ISLAND.

Mining progress near Dolomi has been confined principally to the Valparaiso and Paul claims. On the former there are two shafts 150 and 225 feet deep, and from the deeper one three levels at depths of 90, 150, and 200 feet have been extended along the vein for 175, 350, and 250 feet, respectively. The Valparaiso vein ranges from 4 to 10 feet in width, trends N. 55° W., and dips 30° to 50° NE. On the Paul claim, along the north shore of Paul Lake, several shafts have been sunk from 10 to 80 feet on the vein, and from the bottom of these shafts drifts are being extended. A tramway from these properties to the beach was also completed during the year. No work was accomplished at the Golden Fleece property, just north of Dolomi.

The developments near Hollis were principally on the Julia claim, which was sold early in the year. An inclined shaft 220 feet deep was sunk on the vein deposit, and from this shaft drifts were extended. At the Crackerjack mine operations were in progress from March until June. The other prospects near Hollis were idle during the year.

Gold deposits are being prospected at other localities on Prince of Wales Island and on Dall Island, but as yet they have not become producers.

GRAVINA ISLAND.

Developments at the Gold Stream mine, owned by the Irving Consolidated Mining Company, were in progress during the summer months, but they were not extensive and the 5-stamp mill on the property was idle. The deposit consists of a lode 4 to 8 feet wide inclosed in greenstone schist, and within the lode the principal values are confined to an ore shoot 50 feet in length pitching at an angle of 60° SE. It is developed by a 115-foot shaft and about 600 feet of drifting. A second and wider lode deposit, 100 feet southwest of the first and parallel to it, has been prospected by a shaft and surface trenches, though the ore values in it are lower than those in the smaller deposit. The other prospects on the island were developed to but a slight extent.

CLEVELAND PENINSULA.

Mine developments on Cleveland Peninsula during 1907 were confined to the Gold Standard group of claims at Helm Bay. The deposit at this locality consists of quartz veins in a narrow belt of greenstone schist carrying seams and pockets of rich free-gold ore. The mine is developed by a shaft 115 feet deep and by 700 feet of drifts and tunnels. The surface equipment consists of a compressor plant and a 5-stamp mill. At the other prospects on Cleveland Peninsula assessment work alone was done.

REVILLAGIGEDO ISLAND.

On Revillagigedo Island prospecting has been advanced in a small way at the gold deposits along the shores of Tongass Narrows, George Inlet, and Thorne Arm, though no important developments are noted.

The Sea Level mine, at the head of Thorne Arm, remained idle, though small investigations were in progress on some of the adjoining prospects.

COPPER MINES AND PROSPECTS.

GENERAL STATEMENT.

The occurrence of copper in southeastern Alaska is confined principally to Prince of Wales Island, where it is found in the form of contact-metamorphic deposits adjacent to the granitic intrusives, as at Copper Mountain and on Kasaan Peninsula, and as irregular lenses and masses along the shearing zones in the greenstone schists, as at Niblack. The bulk of the copper ore is chalcopyrite, accompanied by pyrite, magnetite, pyrrhotite, and other sulphide minerals. With one exception, namely, on Copper Mountain, carbonate and oxide ores are practically absent, and the zone of secondary concentration or secondary enrichment is wanting or is too small in extent to be important. In general, it may be stated that where copper ores are being mined in southeastern Alaska the values in the ore will not decrease with increasing depth, though, because of the irregularity of the ore bodies, the rule to observe in exploitation is to follow the ore and not to drive long crosscut tunnels with the expectation of undercutting the deposit in depth. For the most part, the copper ores carry but a small percentage of copper and less than a dollar per ton in gold and require exceptional mining and transportation conditions to insure profitable extraction.

PRODUCTION.

The following table shows the amount and value of the copper, gold, and silver produced from the copper ores in southeastern Alaska during 1906 and the average contents per ton of ore mined:

Production of copper ore in southeastern Alaska, 1906.[a]

	Ore mined.	Copper.		Gold.		Silver.	
		Amount.	Value.	Amount.	Value.	Amount.	Value.
	Tons.	*Pounds.*		*Ounces.*		*Ounces.*	
Total	85,160	4,350,571.00	$839,660.00	3,030.970	$62,851.00	27,152.000	$18,102.00
Average per ton		51.09	9.86	.035	.713	.318	.213

[a] Computations based on average price of copper ($0.193) and silver ($0.67) for 1906.

For 1907 the copper production from southeastern Alaska is estimated approximately at 4,750,000 pounds, valued at $950,000.

KETCHIKAN MINING DISTRICT.

HETTA INLET.

On the west coast of Prince of Wales Island all the important mines and prospects are contiguous to Hetta Inlet, a deep embayment which is connected with the Pacific Ocean through Cordova Bay. The principal mines are centered around Copper Mountain within an area about 8 miles in diameter. An intrusive mass of granodiorite occupies the central portion of this area, and surrounding it are the intruded sedimentary rocks, consisting of limestone and quartzite. At the contacts these sediments are highly altered, and at many localities they have been replaced by ore-bearing minerals, such as garnet and epidote, in which the ore occurs in irregular masses. Overlying the limestone and quartzite and forming the shore outcrops along the east shore of Hetta Inlet are slates and greenstones in which copper deposits occur in the form of veins occupying shear zones parallel to the trend of the inclosing rock. Subsequent to the deposition of the ore there were intrusions of numerous diabase dikes which crosscut the ore bodies and apparently have no genetic bearing on the ore deposits.

The mines and ore bodies have been described in previous reports, and it remains only to discuss the latest developments. At the New York and Indiana mines, on the south slope of Copper Mountain, work was suspended in the fall of 1906, and the properties were idle during 1907. The Jumbo mine, on the north side of the mountain, has been actively developed throughout the year. The aerial tramway from the mine to the wharf was completed early in the year, and ore shipments were begun to the Tyee smelter in British Columbia. The copper deposits under development consist of an irregular body of chalcopyrite ore, 30 to 40 feet wide, 120 feet long, and about 140 feet in depth, occupying a nearly vertical position. The contact zone in which this ore body occurs is 200 feet in length at this point, granite forming the foot wall and limestone the hanging wall. The mine workings consist of four tunnels between 1,500 and 2,000 feet in elevation, the main tunnel being at 1,700 feet elevation and 280 feet long. At a point 180 feet from its mouth a 130-foot vertical raise connects the level with the stopes in the ore body. A lower tunnel has been started at a point 1,570 feet in elevation, on a level with the ore bins at the upper terminal of the aerial tramway, and is to be extended to undercut the present mine workings. To the northeast of the mine, on Jumbo claims Nos. 1, 1A, and 2, a large deposit of magnetite ore carrying copper has been developed, though as yet transportation facilities have not been extended to this locality.

At the Houghton group of claims, owned by the Cuprite Copper Company, which adjoin the Jumbo claims on the east, explorations were in progress during the greater part of the year. The mine workings are at an elevation of 1,600 feet, and an ore body included in the contact zone between the granite and limestone is being developed.

The Corbin mine, owned by the Alaska Metals Company, was operated during the first few months of the year, after which work was suspended and the mine has since been idle. The ore body is a vein deposit, 1 to 3 feet wide, of nearly massive sulphide ore, inclosed in a greenstone schist country rock. It has been developed by a drift tunnel 210 feet in length and a shaft 100 feet deep. From the bottom of the shaft crosscuts were driven to investigate deposits at this depth, but the results are reported not to have been favorable.

The Copper City mine, also known as the Red Wing group, has been developed throughout the year. The ore body is similar to that of the Corbin mine, though the ore contains a higher percentage of copper. The mine is developed by an inclined shaft 120 feet deep, from which two levels at 50 and 100 feet in depth have been extended. From the 100-foot level a winze has been sunk for 60 feet, and from this a third level is being started. Most of the ore above the 100-foot level has been mined.

At the other prospects near Hetta Inlet, namely, the Green Monster group, Hetta Mountain prospects, Gould Island prospects, and Sultana group, little or no development work was accomplished during the year.

KASAAN PENINSULA.

On Kasaan Peninsula are located the principal mines on the east side of Prince of Wales Island, and because of their importance a detailed topographic and geologic survey was made of this area during the last summer. A statement of the results of this work and a description of the mines is contained in a separate paper in this report. (See pp. 98–115.)

NIBLACK ANCHORAGE.

The Niblack mine, on the south side of Niblack Anchorage, has been operated steadily throughout the year. The shaft has been extended to a depth of 320 feet, and from this the 300-foot level is being opened and investigations are being advanced on the 225-foot level. The total underground workings at the close of 1907 were estimated at 5,500 feet. Three large ore bodies have been opened in this mine, besides smaller veins and masses. The north or foot-wall vein is 200 feet in length, averages 20 feet in width and about 100 feet in depth, and has been developed on the 50-foot and 100-foot levels. The south vein, exposed on the 150-foot level, is similar in character, but not so large. The third important ore body has been developed on the 225-foot level and is exposed for 90 feet in length and 15 feet in width. Recent discoveries of new ore bodies containing higher values in copper are reported from the 300-foot level and are being developed. The other properties in Niblack Anchorage were idle except for the assessment work accomplished.

NORTH ARM.

The Cymru mine is located on Mineral Creek, three-fourths of a mile from the head of North Arm. Developments at this mine were in progress the first half of the year, but were then discontinued. The property is developed by a 100-foot shaft from which two levels, at 50 and 100 feet, have been extended. From the mine a tramway 4,200 feet long has been built to the beach, where ore bunkers and a wharf have been erected. The ore bodies are vein deposits from 1 to 10 feet in width, inclosed in a limestone country rock which is interstratified with beds of quartzite and greenstone schist. The ore consists of pyrite and chalcopyrite in a quartz-calcite gangue.

SKOWL ARM.

At the head of McKinzie Inlet, a south branch of Skowl Arm, is the Khayyam mine, owned by the Omar Mining Company. The mine is located 3 miles from tidewater, at an elevation of 2,600 feet. In July, 1907, operations were renewed and were in progress until October, and ore shipments were made to the Tyee smelter in British Columbia. The ore bodies are elongated lenses of sulphide ore coinciding in strike and dip with the schistosity of the inclosing gneissoid diorite country rock. They have been exposed on the surface by open pits and trenches and are crosscut in depth by the Powell tunnel, 220 feet in length. Four ore bodies are exposed in this tunnel, from 6 to 20 feet in width, and have been developed by 350 feet of drifting. The ore is composed principally of pyrite, with a small percentage of chalcopyrite and accompanied by pyrrhotite, sphalerite, and some magnetite.

SILVER, LEAD, AND ZINC PROSPECTS.

Deposits of silver, lead, and zinc ores are not plentiful in southeastern Alaska. They are being developed at only three localities, and from these the metal production has been slight. Silver is present in amounts ranging from one-fifth of an ounce to 3 ounces per ton in the copper ores,[a] and in the gold ores[b] its content is dependent on the amount of gold present, the ratio being approximately 2 ounces of silver to 1 ounce of gold. Lead occurring in the form of galena is being mined in small quantities from the prospects on Coronation Island and the Moonshine prospect in Cholmondeley Sound. Zinc is not known to occur in commercially valuable amounts, though in its sulphide form it accompanies both the copper and gold ores.

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[a] See table for copper production, p. 93.

[b] See table for gold production, p. 86.

The Moonshine prospect is located on the west side of the south arm of Cholmondeley Sound, at an elevation of 2,400 feet. Developments were energetically prosecuted on this property during the year from May until November, though the results attained were not so favorable as was expected. The ore body is a vein deposit occupying a fissure cutting obliquely across limestones and schist country rock and traversing the top of the mountain ridge. Where it crosscuts the limestone it is apparently a replacement deposit, ranging from a few inches to several feet in width; but in the inclosing schists the vein is smaller and is in many places represented by a narrow gouge seam. Throughout the vein the ore occurrence is irregular, the ore being found in scattered masses. It has been developed by a shaft 100 feet deep and at a point 550 feet farther west by a drift tunnel 200 feet in length which is being driven to connect with the shaft at a depth of 225 feet.

Narrow, irregular vein deposits of galena ore have been developed at Egg Harbor, on the north end of Coronation Island. These deposits occur in a limestone country rock, forming small masses along slipping planes, and have been developed by short tunnels at points between 700 and 1,000 feet in elevation.

The silver-lead prospects in Glacier Basin, on the mainland east of Wrangell, are located 7 miles from tide water, at an elevation of 2,200 feet. The ore deposit consists of well-defined quartz veins traceable for long distances along the surface and ranging from 4 to 20 feet in width. The veins are heavily mineralized with galena, zinc blende, pyrite, and chalcopyrite, the principal values being in silver and lead. The properties at this locality were bonded early in the spring and investigation was carried on during July and August, after which period work was suspended.

COPPER DEPOSITS ON KASAAN PENINSULA, PRINCE OF WALES ISLAND.

By Charles W. Wright and Sidney Paige.

INTRODUCTION.

The geologic studies of Kasaan Peninsula carried on during the summer of 1907 by the writers and the topographic map of this area made by D. H. Witherspoon and J. W. Bagley represent the first detailed investigations by the United States Geological Survey in the Ketchikan mining district. The area embraces about 65 square miles between latitude 55° 25′ and 55° 40′ and longitude 132° 5′ and 132° 35′. During the geologic investigations special attention was given to the occurrence of the copper ores and their relation to the different rock formations, and it is expected that the knowledge gained by these studies will indicate where practical exploration may be most advantageously extended in the search for new ore bodies. In this preliminary report only an outline of the geologic facts, tentative conclusions regarding the ore deposits, and brief descriptions of the mines and prospects are presented. The final conclusions may be at variance in certain particulars with those here set forth, inasmuch as the areal mapping was not completed and the notes and collections have not been studied in detail.

GENERAL DESCRIPTION.

Kasaan Peninsula is a promontory on the east side of Prince of Wales Island, 18 miles in length and from 3 to 6 miles wide, projecting into Clarence Strait and sheltering Kasaan Bay. (See fig. 1.) It is a steep, heavily timbered mountain ridge with summits reaching altitudes of 1,000 to 3,000 feet. Near the center of the peninsula a valley nearly separates the mountain range and extends from the "Hole in the Wall" to a point 3 miles southeast of Kasaan. At the northeast end of the peninsula there is also a broad, low, marshy valley 4 miles in length, extending from the head of Tolstoi Bay to a point 3 miles northwest of Kasaan, and another valley 3 miles in length extending from the head of Thorne Bay to the east side of

Karta Bay. The upper limit of timber on the peninsula is from 1,500 to 1,800 feet above sea level; the valleys and gulches contain a dense growth of shrubbery, which renders prospecting difficult. The summits of the ridges are open, except for small clusters of scrub pine.

The relief of the peninsula is typical of the more mature topography of the islands as compared with the rugged, more abrupt topography of the mainland. The mountain summits are dome-shaped and on them lie large erratic bowlders, an evidence of glaciation.

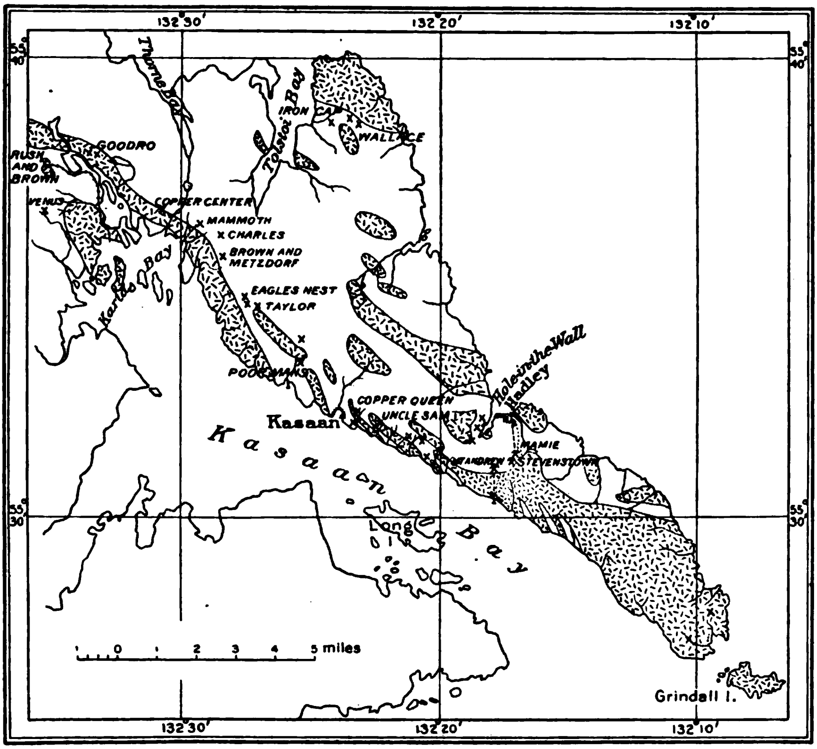

FIG. 1.—Map of Kasaan Peninsula, Prince of Wales Island, showing distribution of intrusive rocks, mines, and prospects.

The valleys, which extend northward from points near the head of Kasaan Bay, are broad and contain many lakes; they are occupied by deep deposits composed of large and small bowlders embedded in glacial clay. The islands and shoals at the entrance to Karta Bay are made up largely of these glacial deposits and represent the terminal moraines left by former ice fields.

The occurrence of copper on Kasaan Peninsula was known to the Russians as early as 1865, but not until 1900 did active mine developments begin. It is now the principal copper-producing area in southeastern Alaska.

PRODUCTION.

The first production of copper from Kasaan Peninsula was made in 1905, the year in which the smelting plant at Hadley was completed. This production continued, gradually increasing in amount, until the autumn of 1907, when all the mines ceased operations. The following tables show the total metal production of the ores derived from the copper mines on Kasaan Peninsula, and the average content per ton of ore.

Production from copper mines on Kasaan Peninsula, 1905 to 1907.[a]

Year.	Ore mined.	Copper.		Gold.		Silver.		Total value.
		Amount.	Value.	Amount.	Value.	Amount.	Value.	
	Short tons.	*Pounds.*		*Ounces.*		*Ounces.*		
1905	20,659	1,194,917	$186,407	932.1	$19,266	5,946	$3,502	$209,175
1906	68,399	3,318,633	640,496	2,413.5	50,078	17,244	11,554	702,128
1907	52,177	2,307,578	461,516	1,282.1	26,500	14,055	9,276	497,292

[a] Average price of metals: 1905, copper, $0.156 per pound; silver, $0.604 per ounce; 1906, copper, $0.193 per pound; silver, $0.67 per ounce; 1907, copper, $0.20 per pound; silver, $0.66 per ounce.

Average content per ton of ore from copper mines on Kasaan Peninsula, 1905 to 1907.

Year.	Ore mined.	Copper per ton.		Gold per ton.		Silver per ton.		Total value per ton.
		Amount.	Value.	Amount.	Value.	Amount.	Value.	
	Short tons.	*Pounds.*		*Ounce.*		*Ounce.*		
1905	20,659	57.8	$9.02	0.045	$0.90	0.29	$0.18	$10.10
1906	68,399	48.7	9.40	.035	.70	.25	.17	10.27
1907	52,177	44.2	8.81	.025	.50	.26	.17	9.51

GEOLOGY.

The rocks which compose Kasaan Peninsula are of intrusive, extrusive, and sedimentary origin. The intrusives include granodiorite, syenite, hornblende diorite, and, more rarely, granite. These rocks invade limestone beds and strata of highly altered sedimentary and pyroclastic rocks ranging from greenstone tuffs to sandstones and conglomerates composed largely of igneous material.

STRATIFIED ROCKS.

The stratified rocks include those of sedimentary and volcanic origin. They occur principally on the northern portion of the peninsula and adjacent to Tolstoi and Thorne bays, and are made up of metamorphosed bedded rocks, usually epidotized and containing amphibole and pyroxene crystals and in places altered to hornfels, quartzite, and mica schists. These range in texture from fine-grained tuffs, slates, and sandstones to conglomerates containing pebbles 2 inches in diameter. The conglomerates are made up of fragments of igneous rocks, as well as of limestone and quartzite. The sandstones and greenstone tuffs are composed largely of volcanic material, and because of their induration they closely resemble massive igneous rocks, though in most places their fragmentary character can be recognized. The limestone beds exposed on the peninsula are entirely recrystallized and both evidence of structure and organic remains are lacking. They are of importance because of their association with and relation to the ore deposits. On Long Island, which occupies the central portion of Kasaan Bay and lies 1 mile southwest of Kasaan Peninsula, occur limestone beds conformably underlain by feldspathic sandstones. Interstratified in these limestone beds near their contact with the underlying rocks are thin beds of sandstone and conglomerate, most of the pebbles in the latter being of porphyry. In the limestone beds themselves Devonian fossils are abundant, and collections at this locality were first made in 1901 by A. H. Brooks, and in 1905 a more complete collection was made by E. M. Kindle. Because of the analogy of these rocks to those on Kasaan Peninsula the latter are provisionally considered to be Devonian.

The structure of the sedimentaries exposed on Long Island is of interest because of the two systems of folding represented—an older system of small folds with a northeasterly strike, and a later system of broader folds which trend to the northwest and belong to the main system of the Coast Range. On Kasaan Peninsula the structure of the bedded rocks has been so greatly interrupted by the intrusive masses that no persistent lines of strike and dip could be followed, though the most prominent direction of the bedding planes was from northwest to west, with a steep dip to the southwest. Two prominent jointing systems are also present on the peninsula—one striking N. 15° to 25° E. with a dip of 60° to 80° SW., and the other striking N. 50° to 70° W. with a steep dip to the northwest.

INTRUSIVE ROCKS.

The intrusive rocks occurring on Kasaan Peninsula all invade the sedimentary strata and are, therefore, of more recent age. (See fig. 1.) The principal intrusive is the granodiorite which forms the entire southern portion of the peninsula and occupies wide areas in the central and northwestern portions. But little is known of the rocks that were intruded into this area previous to the granodiorite, this being the oldest intrusive rock recognized. The granodiorite intrusives, however, vary considerably in composition and probably represent several periods of igneous invasion during one general epoch, though in some of them this difference can undoubtedly be attributed to segregations within the igneous magma during solidification.

After the granodiorite invasion granite and syenite dikes, some of them many hundred feet in width, were intruded, besides numerous dikes of pegmatite and aplite. Somewhat later, or possibly during the same period, rocks more basic in composition intruded the area, also in the form of dikes. These were followed by felsitic dikes from 1 to 100 feet in width. Still more recent are the diabase and basaltic dikes, both of which are later than the ore bodies.

ORE DEPOSITS.

The occurrence of ore on Kasaan Peninsula is similar to that in the vicinity of Hetta Inlet. The ore bodies are contact-metamorphic deposits, occurring usually at the contact of an intrusive syenite mass with limestone or, in some places, with greenstone tuff or conglomerate. They are included in a garnet-epidote gangue and are generally associated with magnetite, this mineral forming in many places half of the gangue. The principal mineral zone defined on this peninsula follows the contact of a syenite intrusive mass with a narrow belt of limestone, and is traceable from the east side of Mamie Creek for 2 miles in a westerly direction. This zone ranges from 100 to 300 feet in width, though, because of its flat dip and its conformity with the contour of the mountain slope, it appears locally to be much wider. The Mamie, Stevenstown, and Mount Andrew mines are included within it. Another smaller zone, with a diorite intrusive on the southwest side and both limestone and greenstone tuff to the northeast, extends along the western side of the peninsula about 1 mile inland, beginning 3 miles northwest of Kasaan and continuing northwestward to Karta Bay. The Sea Island, Haida, and Copper Center prospects are included in this belt. Besides the contact-metamorphic deposits, copper ores associated with quartz occupy shear zones in the greenstone tuff and conglomerates at the head of Karta Bay, being found in the Rush & Brown mine at the Venus prospect. On the east side of Karta Bay bornite and chalcopyrite occur in small masses and disseminated throughout a basic diorite intrusive belt on the Goodro and Stevens prospects.

The extent of these various ore bodies depends largely on the type. The contact-metamorphic deposits are generally irregular masses of small extent, as a rule no more persistent in depth than they are laterally; but where the contact zone is more extensive, investigations within it will probably reveal similar ore masses both laterally and in depth. The copper-iron-sulphide deposits occupying shear zones in the stratified rocks are more persistent than the contact ore bodies and will probably extend to a considerable depth.

The principal copper mines in the region are developing deposits of a low-grade copper-iron-sulphide ore which can be profitably exploited only by extreme economy in extraction. At certain mines the accessory gold content of $1 to $2 per ton is depended on to raise the total value of the ore above the commercial limit. The copper ores generally contain high percentages of iron and lime and are classed as "base ores." To accomplish their reduction, therefore, it is necessary to mix them with siliceous or quartz ores. The lack of available siliceous ore has been a serious handicap to the smelters of the district. Increasing the value of the copper ores by concentration alone would as a rule be of little advantage, both because of the high percentage of iron minerals and because only the lighter siliceous minerals, which are necessary as a flux, would be separated. Some of the ores, however, might with advantage be ground and treated in a magnetic separator.

These facts are clearly brought out in the following table, which shows the composition of the gangue content of the ores from the principal mines as determined by smelter assays.

Smelter assays of ores from copper mines in the Kasaan Peninsula.

Name of mine.	Silica (SiO_2).	Iron (Fe).	Lime (CaO).	Sulphur (S).	Alumina (Al_2O_3).
Mamie:					
Siliceous ore	30.6	17.5	10.4	5.9	17.2
Base ore	10.6	47.8	2.7	6.3	7.7
Stevenstown	16.4	34.1	7.6	6.9	11.7
Mount Andrew	15.2	42.8	.4	4.3	----------
Karta Bay	16.5	35.6	6.8	6.2	----------
	19.6	28.3	7.0	8.0	----------

The preceding analyses, though incomplete, show the relative basic and siliceous content of the ores. The portion of the analyses not given represents the moisture (H_2O), the carbon dioxide (CO_2), the undetermined elements, including the alkalies contained in the ores, and also their content of precious metals.

MINES AND PROSPECTS.

MAMIE MINE.

Situation and development.—The Mamie mine, owned by the Brown Alaska Company, is situated 1¼ miles south of Hadley, in the central portion of Kasaan Peninsula, at an elevation of 700 feet. (See fig. 1.) The mine workings are connected with the smelter at Hadley both by an aerial tram 5,500 feet in length and by a horse tram 7,700 feet in length. The horse tram is used for the transportation of supplies. Mine developments in a large way were not begun until 1904. During that year the ore bodies were explored by numerous open cuts, tunnels, and diamond-drill holes. In the following year mining of the ore was begun from the open pits and new ore bodies were developed by tunnels and shafts. At the close of 1905 considerable ore was delivered to the smelter and throughout 1906 the production was large. In 1907 diamond-drill investigations were advanced, new ore bodies were located at greater depth, and the ore production continued with little interruption until late in September. In October all operations were suspended. The total developments consist of 5,000 feet of tunneling, drifting, and crosscutting and about the same amount of diamond-drill prospecting.

The smelter or reduction plant at Hadley, belonging to the Alaska Smelting and Refining Company, is controlled largely by the owners of the Mamie mine. It consists of a blast furnace of 350 tons daily capacity, a sampling mill, coal and coke bins, ore bunkers of 10,000 tons capacity, boiler house, engine house, electric-light plant, and other conveniences. The ores from the Mamie and Stevenstown mines first go through the samplers, next to the ore bunkers by gravity, and thence by gravity to the furnace. The slag from the furnace is granulated and carried by water to the beach. A cable tramway extends from the wharf to bins above the sampling mill, which have been built to receive custom ore. The plant is so arranged that its daily capacity may be doubled if necessary. Smelting operations began December 5, 1905, and in 1906 the furnace was in blast about twenty days each month. In September, 1907, this plant was closed.

Ore bodies.—The ore bodies at the Mamie mine are contact-metamorphic deposits included in a zone 400 feet wide lying between a syenitic intrusive and limestone. Within this zone the masses of valuable copper ore are defined either by such a decrease in the copper content of the inclosing rock as to prohibit profitable extraction or by fault planes. Garnet, epidote, and magnetite compose the contact rock, throughout which chalcopyrite is present in small quantities. The ore bodies, or portions of the contact rock where the concentration of the copper values is sufficient to make ore, are irregular masses ranging from 50 to 100 feet in length and thickness and from 10 to 40 feet in width, the major axis striking northward. Nine such ore masses are exposed in the mine workings. Some of them are included entirely in magnetite masses, forming basic ore; others occur in the garnet-epidote gangue, making a siliceous ore. Small veinlets of calcite, and rarely quartz, intersect the ore masses, thus indicating a later period of mineralization, though the main ore bodies are believed to have been deposited contemporaneously with the inclosing contact rock.

STEVENSTOWN MINE.

Situation and development.—The Stevenstown mine, owned by the Hadley Consolidated Copper Company, is situated just above and southwest of the Mamie mine, at an elevation of 1,000 feet. (See fig. 4.) From the mine a surface tram 700 feet long connects with the aerial tram at the Mamie mine, over which the ore is transported to the smelter at Hadley. A trail also leads from the mine down the south side of the peninsula to Boggs Landing, on Kasaan Bay, a distance of 1 mile. The mine has been developed by three "glory holes" or open pits connected by raises with a 550-foot tunnel penetrating the crest of the mountain. Actual mining developments were begun in June, 1905, previous to which prospecting alone had been carried on; and in September of that year ore shipments to the Hadley smelter began. A large amount of ore was produced during 1906 and until July 1, 1907, when mining operations were suspended.

Ore bodies.—The ore bodies on the Stevenstown property correspond both mineralogically and genetically with those at the Mamie mine. They occupy a relatively flat position on the crest of the mountain ridge and are apparently underlain by the syenite intrusive which forms the foot wall of the mineral belt and which is exposed throughout the tunnel that penetrates the mountain top. The hanging wall, as well as a large portion of the ore bodies on this property, has been removed by erosion and the contact zone is only from 20 to 40 feet in width, instead of 200 to 400 feet, the width on the Mamie property just below. To the northeast of the ore bodies strata of limestone and greenstone tuff occur and continue westward toward the Mount Andrew mine, forming the hanging wall of the mineral zone.

The mine workings are all surface pits connected by raises with the main tunnel, and in these several relatively flat-lying ore masses have been developed. These masses are included within an area 350 by 200 feet, the pit being from 20 to 40 feet deep. The central portion of this area is traversed in a southerly direction by a 40-foot felsite dike, which is of later intrusion than the syenite and crosscuts the ore body. Smaller dikes of diabase and basalt 1 foot to 5 feet in width were observed crosscutting the ore bodies and country rock at several points in the mine workings.

The ore is composed largely of magnetite, chalcopyrite, and pyrite associated with hornblende and calcite, all of which are included in a more or less banded garnet-epidote gangue.

Surface oxidation has produced considerable limonite and some malachite and azurite; small particles of native copper also occur along slipping planes. These secondary minerals are relatively unimportant.

MOUNT ANDREW MINE.

Situation and development.—The Mount Andrew mine workings are situated three-fourths of a mile from Mount Andrew Landing, on the southwest side of Kasaan Peninsula, and one-half mile west of the Stevenstown mine, at an elevation of 1,400 feet. A cable tramway 3,600 feet long leads from the mine over a 1,440-foot knoll just south of the workings to the ore bunkers and a wharf at Mount Andrew Landing. (See fig. 1.)

This mine is developed principally by a tunnel 620 feet long, undercutting the ore bodies from 60 to 100 feet or more in depth. From this tunnel several hundred feet of drifts and crosscuts have been driven, and upraises have been extended through the ore bodies to the surface. The ore is mined out of large underground stopes and from surface pits or "glory holes," and is delivered through chutes at the tunnel level to the ore bunkers at the head of the aerial tram and thence carried to the wharf, where it is loaded for shipment. Developments in a large way were not begun until late in 1905, and during 1906 the aerial tram was erected, the wharf built, the compressor plant installed, and considerable ore developed. The first ore shipments were made in October, 1906, and production continued until October, 1907, when operations were suspended.

Ore bodies.—The ore deposits on this property are included in the same mineral belt as those at the adjacent Mamie and Stevenstown mines, with which they are in every way comparable. Six ore bodies consisting of irregular magnetite-chalcopyrite masses associated with the garnet-epidote contact rock have been developed and mined to a considerable extent. These bodies of ore are 10 to 50 feet wide, 40 to 80 feet long, and 100 feet or more in depth, and have a general northerly strike and pitch. They are separated by barren areas of contact rock cut by dikes 20 to 60 feet wide of altered syenite porphyry. The mine workings consist essentially of surface pits which are undercut by a crosscut tunnel running east and west. This tunnel with connecting drifts and raises includes 2,200 feet of underground developments. Numerous gouge seams and slickensides indicating faulting were observed in the mine workings, and lateral displacements of the ore bodies for 1 to 6 feet were also noted. Dikes of diabase and felsite 2 to 12 feet wide crosscut the ore bodies and country rock in various directions and were evidently intruded later than the formation of the ore deposits.

At other points on Mount Andrew large masses of magnetite carrying but a small percentage of copper, insufficient in amount to make a copper ore, have been developed. These deposits, though not valuable for copper alone, may at some future time be of importance as a source of iron ore.

RUSH & BROWN MINE.

Situation and development.—The Rush & Brown property includes eight claims extending northwestward from the "Salt Chuck," the principal mine workings being located on the Iron Cliff claim, about 2 miles from the wharf at the head of the bay, at an elevation of 300 feet. (See fig. 1.) In 1904 this property was prospected by long trenches and open cuts, and a shaft 25 feet deep was sunk on the ore body. In 1905 it was leased by the Alaska Copper Company, and a new shaft was started 120 feet south of the old shaft and sunk to a depth of 100 feet. From the bottom of this shaft the principal ore body, the magnetite deposit, was developed by drifts and crosscuts and a drift was extended to a second ore body, the sulphide deposit, 160 feet farther northeast. At the close of 1907 the greater portion of these ore bodies had been stoped out and the shaft sunk for an additional 100 feet, to a point from which a 200-foot level was started. The ore from the mines is transported by a gravity tram to ore bunkers one-fourth mile below the mine, and thence by a railroad 2¾ miles long to the wharf at the head of the bay, where ore bunkers of 2,000 tons capacity have been built. During 1906 ore was shipped to the smelter at Coppermount, and in 1907 shipments were made to the Tyee smelter at Ladysmith, B. C.

Ore bodies.—Two ore bodies have been developed at the Rush & Brown mine. One is a contact-metamorphic deposit consisting of a copper-bearing magnetite body 100 feet long by 30 feet wide in a garnet-epidote-calcite gangue lying between granodiorite and an indurated greenstone tuff, the line of contact striking nearly east and west. The other deposit, 160 feet to the north, occupies a shear zone in the greenstone tuff and conglomerate beds and is a sulphide body composed of pyrite and chalcopyrite in a quartz-calcite gangue. It is from 4 to 8 feet in width and has been developed over a length of 85 feet. The strike of this sulphide deposit is northeastward and its dip 60° SE., toward the larger deposit.

UNCLE SAM MINE.

Situation and development.—The Uncle Sam mine, originally called the White Eagle group, lies 3 miles northwest of Mount Andrew Landing and half a mile from Kasaan, on the south slope of Kasaan Peninsula. (See fig. 1.) The mine workings are 430 to 550 feet in elevation and less than half a mile from the beach. Mining operations have been conducted on this property at various intervals since its discovery in 1899, and in 1901 an aerial tram, ore bunkers, and a wharf were built. Early in 1906 a shipment of ore was made, but no further work was done until March, 1907. At that time operations were renewed, continuing until July, when another ore shipment was made. The mine is developed by a tunnel and drifts amounting to about 800 feet in length, and by open pits exposing the ore body on the surface above the tunnel. From this working tunnel a surface tram, 1,150 feet long, conveys the ore to the wharf.

Ore body.—The ore body exposed in the tunnel consists of an irregular lens of chalcopyrite-pyrite ore 6 to 8 feet in width, striking north and south and pitching about 45° N. It is cut off to the north by an east-west fault dipping 80° N., which shows but a small amount of gouge. At the open cut above the tunnel similar masses of ore are exposed, but no large ore bodies have been defined. Garnet, epidote, magnetite, and calcite occur as gangue minerals and in many places form small geodes. The chalcopyrite ore contained in this gangue is irregularly distributed in small masses and not along definite lines. The country rock is made up of strata of chloritized and epidotized greenstone tuff, which is underlain by the intrusive syenite and crosscut by small dikes of diabase, of later origin than the ore bodies.

COPPER QUEEN GROUP.

The Copper Queen group of claims, which represents the first copper locations on Prince of Wales Island, lies about half a mile southeast of Kasaan. In 1898 these claims were sold to the Kasaan Bay Mining Company, which made additional locations. Small operations were in progress from 1899 until 1902, and 500 feet of tunneling was done besides surface excavations. Since 1902 the property has been idle.

The principal ore deposit is exposed along the side of a gulch at a point 300 feet in elevation. It consists of an irregular mass of chalcopyrite ore accompanied by pyrite and magnetite in a garnet-epidote gangue at the contact of an altered intrusive syenite with the greenstone tuff. Below these exposures a crosscut tunnel 400 feet in length has been driven in the altered syenite, but has failed to reveal any ore.

Other mineral exposures occur on these claims at points close to tide water and have been prospected by shafts and open cuts, but so far no important deposits have been discovered.

POOR MAN'S GROUP.

The Poor Man's group of two claims is located 2 miles northwest of Kasaan (see fig. 1), and the mine workings are connected with deep water by a surface tramway and wharf, having a total length of about 2,000 feet. The principal developments are at the head of the tramway and consist of a tunnel driven 90 feet in a southwesterly direction which crosscuts a 60-foot body of massive magnetite and 10 feet of garnet-epidote contact rock and at its face enters a dike of red felsite 20 feet wide. At a point 20 feet from the mouth of the tunnel is a vertical shaft extending 30 feet to the surface and 60 feet in depth. This body of magnetite is exposed on the surface above the tunnel and similar masses have been prospected by short tunnels and cuts and shafts at points along the tramway and on adjoining properties. Associated with the magnetite are large amounts of calcite and hornblende, some pyrite and chalcopyrite, and garnet and epidote. Although the magnetite deposit itself is extensive the chalcopyrite ore occurs only in isolated pockets or narrow veinlets and is not disseminated throughout the magnetite in sufficient amounts to make a copper ore of the entire body. It is noteworthy, however, that these ore bodies may be of value for their iron content. Minor displacements, due to faulting or slipping planes, and dikes of diabase and felsite crosscutting the deposits were noted.

EAGLE'S NEST GROUP.

The Eagle's Nest group of claims, situated 4 miles northwest of Kasaan, was first located in 1906 and in the same year was bonded to the Sea Island Copper Mining Company. Operations by this company were begun in October, 1906, and continued in a small way until September, 1907, when the property reverted to the owners.

The developments have been confined to the mineral exposures on the Alarm claim at an elevation of 400 to 500 feet. On the southeast end of this claim is a 70-foot tunnel essentially in a garnet-epidote rock in which a small amount of ore occurs near the face. Just above the tunnel a body of magnetite-chalcopyrite ore 8 feet wide and 20 feet long is exposed in an open cut, beneath which are beds of limestone. Above this, near the summit of the ridge, is an open cut and a shaft 12 feet deep exposing small amounts of ore associated with garnet in limestone. On the northwest end of this claim an open cut and a shaft 35 feet deep exposes masses of chalcopyrite associated with various contact minerals in a coarsely crystalline limestone. Below these workings diorite is exposed and forms the lower portion of the ridge. No large copper deposits have been developed on these claims, though further investigation may reveal important ore bodies.

TAYLOR PROSPECT.

The Taylor prospect, located early in 1907 as the It claim, adjoins the Eagle's Nest group on the east. On this prospect, at a point 600 feet in elevation, a body of chalcopyrite ore in a gangue of garnet and epidote has been exposed by surface cuts over an area of 20 to 40 feet. The ridge to the southwest, on the foot-wall side, is composed of diorite, and below the prospect to the northeast limestone beds are exposed.

MAMMOTH GROUP.

Situation and development.—The Mammoth group lies on the east side of Karta Bay, about 6 miles from Kasaan and one-third of a mile from tide water. on the top of a low hill 500 feet in elevation. This property was largely developed in 1904–5 by the original owners, and in June, 1906, was sold to the Haida Copper Company, which began active developments and made plans for the erection of a gravity tram 2,000 feet in length to the beach, and for a wharf and ore bunkers. In April, 1907, these improvements were completed, and the company made shipments of ore to the Hadley smelter. Early in the summer, however, operations were suspended, and the mine has since been idle. The mine is developed by a tunnel 120 feet in length connecting with a shaft 35 feet deep, which in turn connects with a surface pit on the ore body. Exploratory drifts have been extended from the tunnel, and prospect pits and short tunnels have been driven at other points on the property.

Ore body.—The ore body is an irregular magnetite mass carrying chalcopyrite in a gangue of garnet and epidote. The country rock in the immediate vicinity is altered greenstone, tuff, and conglomerate, though just below the workings a belt of intrusive diorite is exposed which forms the western half of the ridge and probably underlies the ore body. The deposit is developed by an open pit over an area about 50 feet in diameter. This is undercut by a tunnel at a depth of 30 feet, and, though the magnetite is exposed at this depth, chalcopyrite is not so abundant. To the northeast the ore body is limited by a fault plane striking nearly east and west and dipping 75° S. Other slipping planes striking at different angles were noted in the ore body and inclosing rock.

GOODRO CLAIMS.

The Goodro claims, also known as the Joker group, are located one-half mile from the head of the "Salt Chuck" entering Karta Bay. (See fig. 1.) The surrounding area is relatively low, the claims being located on a knoll about 400 feet in elevation. The copper deposit at this locality is of special interest because bornite is the dominant ore, and it is the only locality in southeastern Alaska where bornite has been found in quantity. This ore occurs in small masses and disseminated particles associated with epidote, feldspar, and biotite, and is inclosed in a basic diorite which is largely replaced by these minerals. Native gold and considerable chalcopyrite also occur with the ore, and near the surface small amounts of chalcocite and native copper were noted. The diorite forms an extensive belt half a mile wide striking in a northwesterly direction. Laterally this mineralization is exposed across a width of 60 feet and for about 100 feet in length. It has been developed by a surface pit 12 feet deep, by a cut 70 feet long, and by a tunnel 125 feet long which crosscuts the ore-bearing mass 90 feet below the surface and 90 feet from its mouth. Slipping planes were observed at several points, but do not appear to have caused any noteworthy displacements. In an open cut a diabase dike is exposed which is evidently younger than the ore deposit. Early in 1907 an ore shipment was made to the Hadley smelter and is reported to have yielded good values in both copper and gold.

TOLSTOI BAY PROSPECTS.

General description.—On the north end of Kasaan Peninsula adjacent to Tolstoi Bay, which forms a good anchorage to the west, considerable prospecting has been done and numerous locations have been made, but none of the properties have been developed beyond the prospecting stage. The small promontory here is composed largely of the granodiorite intrusive masses, which are exposed at Tolstoi Point and along the eastern slope of Tolstoi Mountain. On the western slope and along the east shore of Tolstoi Bay greenstone tuff, sandstone, and conglomerate and a few strata of limestone form the rock exposures. Both the bedded and the intrusive rock masses are crosscut by dikes of porphyry and diabase. The ore bodies are contact-metamorphic deposits similar in character to those at the mines on the southern part of the peninsula. They are lenticular masses of magnetite carrying chalcopyrite and associated with garnet, epidote, calcite, and quartz, inclosed in the bedded rocks near the intrusive granodiorite contact.

Iron Cap group.—The Iron Cap property, also known as the Mahoney group, consists of two claims located on the northwest slope of Tolstoi Mountain at an altitude of 1,000 feet, and is reached by a trail 1½ miles long starting from a cove 2 miles southwest of Tolstoi Point. In 1901 the property was prospected to a considerable extent by open cuts along a gulch and by several hundred feet of diamond-drill holes, but since that time it has been idle. The country rock consists principally of greenstone tuff and a fine conglomerate intruded by syenitic dikes of considerable width, which are apparently related to the ore deposits. Three ore bodies have thus far been located, the largest being 20 feet in width and traceable for 50 feet in length, the major axis striking N. 45° W. A second ore body, separated from the first by a 30-foot dike of altered syenite, is 12 feet in width and is limited on the foot-wall side (to the southwest) by a fault plane showing a considerable gouge seam; toward the hanging wall it grades into a garnet-epidote contact rock. The third ore body, which lies just above the other two at an elevation of 1,080 feet, appears to be a flat-lying magnetite deposit only a few feet in thickness.

Wallace group.—The Wallace group includes four claims situated on the southeast slope of Tolstoi Mountain between 800 and 1,600 feet in elevation. At several points on this property small scattered masses of copper ore are exposed, but at no place have investigations been sufficient to determine the extent of these deposits. The uppermost ore exposures have been opened by a short tunnel in which a vein of garnet-epidote rock is shown containing chalcopyrite and striking N. 15° W. and dipping 20° SW. At the lower openings a magnetite-chalcopyrite ore is exposed, but the bodies do not appear to be extensive.

Tolstoi group.—The Tolstoi group of claims is located south of the Wallace group, just below the summit of Tolstoi Mountain. The ore bodies are low-grade magnetite-chalcopyrite masses similar to those on the Iron Cap group, but they have not been so extensively prospected. No developments more than the required annual assessment work have been accomplished on this property.

Big Five claim.—The Big Five claim lies half a mile east of Tolstoi Bay, on the trail to the Iron Cap group, at an elevation of 370 feet. A tunnel 50 feet in length and a shaft expose scattered masses of chalcopyrite, pyrrhotite, and pyrite in a gangue of garnet, epidote, and calcite, the deposit being 10 feet wide. This deposit is a replacement in limestone beds and many slipping planes defined by gouge seams traverse both ore body and country rock. Assessment work only is done on this claim each year.

OTHER PROSPECTS.

Venus prospect.—The Venus group of claims is located on Crow Creek 1¼ miles from the head of Karta Bay and about 1 mile southwest of the Rush & Brown mine. (See fig. 1.) This property was located in 1904 by a magnetic survey by U. S. Rush, and at the point of maximum attraction a pit was sunk and a trench 50 feet in length exposing the magnetic deposit was made through the overlying débris. Below these surface excavations, which are at an elevation of 250 feet, a tunnel 75 feet in length has been driven which crosscuts 50 feet of débris and 25 feet of country rock, and at its face exposes ore. The country rock is an indurated greenstone tuff with interstratified quartzite beds, the ore occupying a shear zone. Associated with the ore is considerable sphalerite and pyrrhotite, with quartz and calcite as gangue minerals.

Copper Center prospect.—The Copper Center prospect lies 1 mile north of the Mammoth group, at an elevation of 400 feet. It was located in April, 1907, and in July was bonded to mining men who undertook its development. Several shafts from 10 to 30 feet deep were sunk within an area 300 by 120 feet. In all these shafts and surface cuts a magnetite and chalcopyrite ore associated with a garnet, epidote, and hornblende gangue is exposed. The deposit is apparently flat lying, though the amount of work done is hardly sufficient to prove that it does not continue in depth. It is also probable that further investigations at a greater depth will reveal deposits at other points on the property. The country rock is largely conglomerate and greenstone tuff, which are underlain by granodiorite, exposed down the hillside to the southwest. The area is densely covered by undergrowth, which renders prospecting difficult. The dip needle has been successfully used within this area and the deposit just described was located by it.

Charles prospect.—The Charles property lies about 1 mile southeast of the Mammoth group and 5,000 feet from tide water, at an elevation of 380 feet. It was located in May, 1907, and only a small amount of work has been done on it. The mineral body exposed in a cut 20 feet long and 10 feet deep consists of chalcopyrite masses associated with some magnetite in a garnet gangue which replaces the greenstone tuff country rock. Granodiorite occupies the hill just west of this prospect, but was not exposed near the mineral body. Dikes of diabase crosscut the ore body and are evidently of later origin. Besides the copper, the ore is said to carry high values in both gold and silver.

Brown & Metzdorf prospect.—The Brown & Metzdorf prospect is located three-fourths of a mile south of the Charles prospect and one-half mile from Kasaan Bay, at an elevation of 310 feet. The ore body is a mineralized mass of garnet rock carrying chalcopyrite and pyrite exposed for a width of 10 feet, showing a banded structure and evidently replacing the bedded quartzite and greenstone tuff country rock. A wide belt of limestone is exposed in bluffs along the trail just below this prospect.

Peacock and Tacoma claims.—The Peacock and Tacoma claims, about 3 miles southeast of Kasaan post-office (see fig. 1), are the property of the Grindall Mining and Smelting Company. The Tacoma claim is located along the beach, where open cuts have been made on ore exposures that are covered at high tide. The ore is confined to a garnet-epidote rock and occurs in irregular patches or finely disseminated particles. In the beach cuts a small amount of ore is exposed, and above it, at an elevation of 50 feet, is a tunnel 60 feet in length entering the hill in a northeasterly direction. This tunnel crosscuts a wide belt of garnet-epidote rock containing some chalcopyrite. Other open cuts expose small amounts of ore at several places, but no large ore masses have been developed.

The Peacock claims adjoin the Tacoma claim on the north and extend to the center of the peninsula. At 600 feet from the beach and 120 feet above tide a tunnel 45 feet long exposes a belt of garnet-epidote contact rock containing magnetite and a small amount of chalcopyrite. Still higher, at 325 feet, a second tunnel 30 feet long, following the contact of a diabase dike, exposes a similar mineral-bearing rock. Here also dikes of felsite and basalt occur, and slipping planes were observed faulting the mineral body in various directions. The amount of development on these properties has not been sufficient to disclose ore bodies large enough to justify mining, but systematic prospecting may open up deposits of value.

"Hole in the Wall" prospects.—The small cove known as "Hole in the Wall" lies on the north side of the harbor at Hadley, and along its shores and west of it a number of claims have been located, among which are the Plumley group and the Eureka, Sunrise, Pennsylvania, Venus, and Pelaska claims. (See fig. 1.) On the Hilma claim of the Plumley group, at a point one-half mile northwest of the head of the cove and 310 feet in elevation, a tunnel 25 feet in length has been driven along the contact of an altered limestone belt with a dioritic batholith, in which small masses of chalcopyrite are exposed in a garnet-epidote-calcite contact rock. On the Eureka claim, at tide water, similar contact deposits are being developed and are reported to be of considerable extent. The Sunrise claims, three in all, are located west of the "Hole in the Wall," and on these claims at points along a gulch small ore masses occur replacing limestone beds at or near their contact with granodiorite. At 1,050 feet elevation this contact aureole is 25 feet in width and contains considerable magnetite and chalcopyrite ore which shows much surface alteration. On the south slope of the hill at 950 feet elevation is an open cut exposing a highly crystalline marble, slightly banded, striking N. 65° E. and dipping 60° NW. This marble overlies the contact rock, which carries small amounts of the copper ore. On the Pennsylvania claims, southeast of the Sunrise claims, an open cut following a felsite dike at 850 feet elevation exposes a small vein 2 to 3 feet wide consisting of pyrite with small amounts of chalcopyrite. The prospects on the Venus claims show contact deposits similar to those exposed on the Sunrise claims to the north and are apparently along the same intrusive contact. The Pelaska claim, extending from the head of the cove westward, has been developed by a tunnel over 100 feet in length following a belt of altered limestone intruded by a diabase dike, along which occurs the garnet-epidote contact rock carrying some chalcopyrite. This deposit is interesting geologically, but the amount of ore exposed is small.

PRACTICAL DEDUCTIONS.

From the foregoing considerations it is evident (1) that the ore bodies should be sought along or near the contacts of the intrusive diorite and syenite masses; (2) that the contacts of large intrusive masses are more favorable for ore deposits than those of small masses; (3) that the limestone beds are more likely to be replaced by the ore-bearing minerals than the other intruded rocks, because of their solubility; (4) that the largest deposits are found at the contacts of limestone with the intrusives, as the lime carbonate acts as a precipitant to the ore minerals; (5) that the felsite, diabase, and basalt dikes are later than the ore bodies and have no genetic relation to them; and (6) that ore bodies may be found at considerable depths within the contact zones as well as near the surface.

Though large areas on Kasaan Peninsula still remain unprospected, there is little to indicate that deposits of much higher grade or of greater extent than those that are being mined at present will be found.

The question as to the extent of the copper-bearing masses is possibly the most vital one. That outcrops may fail altogether to indicate the value of the ground underneath has been shown at several localities, and that the ore may occur in masses of moderate size, which can be mined out in a short time, is shown at several mines, though at these localities further investigation has usually revealed new ore bodies. Under exploitation on the scale which prevails in this district the problem of new ore reserves must inevitably come to the front, and the search for new ore bodies should be vigorously continued by both prospector and mine operator. Such investigations have been satisfactorily prosecuted in the ore-bearing rocks by the use of diamond drills, which are especially adapted to the search for scattered ore masses.

Under existing conditions, with the price of copper at 15 cents a pound, it is not possible to mine profitably ore containing less than 60 pounds of copper and the usual gold content of 75 cents to $1.25 per ton. However, ore containing as low as 40 pounds of copper per ton was mined and shipped at a profit early in 1907, when the market value of copper was 25 cents a pound. The present mining costs average from $1.50 to $2 per ton, including haulage to the wharf; transportation to the smelter at Tacoma or in British Columbia costs from $1.50 to $2 per ton, depending on the tonnage shipped; smelting charges are from $3 to $5 per ton, including the losses in treatment. When the ore is smelted in Alaska, the cost of transportation is somewhat reduced, though the smelting charges are necessarily increased, as the coke required must be shipped to Alaska and the copper matte or smelter product shipped to Puget Sound.

Large bodies of magnetite containing from 0.5 to 1.5 per cent of copper have been developed in the mines and on several prospects. Such deposits can not be mined as copper ore with profit. It may be possible, however, by a method of concentration, by fine grinding and magnetic separation, to produce a marketable product from this low-grade material. The value of these magnetite deposits as iron ore should also be considered. Analyses show that the magnetite is practically free from phosphorus and contains very little sulphur or other impurities. It might therefore be placed on the market as a Bessemer ore.

THE BUILDING STONES AND MATERIALS OF SOUTHEASTERN ALASKA.[a]

By Charles W. Wright.

GENERAL STATEMENT.

The only stones of value in southeastern Alaska, so far as known, are the marbles and granites. The market for these stones is in the cities along the Pacific coast of the United States, 600 to 1,000 miles distant. They must, therefore, be of more than ordinary quality to bear the expense of freight, as good stone is found in the vicinity of most large cities, and builders, as a rule, prefer to use a known rock which is near at hand and can be readily obtained.

To place the Alaskan product on the market, it will be necessary to establish supply stations with dressing and cutting plants in the larger seaboard cities, where cheaper and more efficient labor may be obtained than in Alaska. To supply these points the rough granite and marble could be transported in hulks or barges carrying several thousand tons at a low freight rate, and the necessity of careful handling during the shipment would be avoided.

To determine the structural value of a building stone, microscopical, chemical, and physical tests should be made. This is more necessary for marble and cement stone than for granite. Most university laboratories are equipped for such tests and will make them at a reasonable cost.

Deposits of building materials, such as cement, gypsum, and clay beds, are not plentiful in southeastern Alaska, and gypsum alone is being mined at a profit. Both cement and clay deposits have been located, but no attempt has been made to place the material on the market.

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[a] The substance of this paper was published in last year's Progress Report (Bull. U. S. Geol. Survey No. 314, pp. 73–81), but as the edition of that bulletin is almost exhausted it seems advisable to reprint here these statements, which are supplemented by descriptions of the progress at the mines and quarries in 1907.

MARBLE.

DISTRIBUTION.

Beds of marble are known to occur at points along the mainland portion of southeastern Alaska, as well as on many of the islands. They are invariably at or near the contact of an intrusive belt of granodiorite, which has been one of the principal factors in metamorphosing the original limestone beds to their present crystalline or marbleized condition. The age of the limestone beds is Paleozoic, and only in a few places could a more definite determination be made. The largest deposits of marble under development are at the northwest end of Prince of Wales Island near Shakan and on Ham Island south of Wrangell.

NECESSARY QUALITIES.

Commercially, marble includes all limestone rocks susceptible of receiving a good polish and suitable for ornamental work. It is not a simple matter to judge the value of a marble deposit, and this can not be done from mere tests of small samples, which, nevertheless, may often give significant results. Some of the more important factors governing the value of a body of marble are the quality and soundness of the stone as a whole, extent of the deposit, absence of fractures or joint planes, color, lack of objectionable impurities such as silica, pyrite, and bitumen, facility of extraction, and location of the deposit relative to the market and transportation.

ALASKA MARBLE COMPANY.

SITUATION AND DEVELOPMENT.

The properties of the Alaska Marble Company are situated on Marble Creek a few miles north of Shakan, Prince of Wales Island, bordering the coast for 2 miles and being over half a mile in width. They are located upon a belt of Devonian limestone about 3,000 feet in width flanking the west side of an intrusive granite mass which forms the low mountain ridge to the east and which is evidently the direct cause of the alteration of the limestone to marble. This deposit was first discovered in 1896 and finally located in 1905, the first work being done along the exposures in the creek bed half a mile from the shore. From 1900 to 1904 prospecting was extended up the hillsides and drill holes were sunk to ascertain the quality of the product in depth. Early in 1904 the Alaska Marble Company was incorporated, and developments on a large scale were immediately begun. At present the plant consists of a wharf equipped with derricks, a gravity railroad to the quarry, 3,200 feet in length, necessary channeling and gadding machines, and various buildings. At the quarry, located on the south side of Marble Creek at an elevation of 100 feet, an area 100 by 200 feet has been stripped and quarried to an average depth of 60 feet, measured on the mountain side.

A test shipment of 100 tons was made in 1902, but actual production did not begin until 1906. The marble is now being placed on the market in the cities along the Pacific coast. The manufacturing plant of the company is located at Tacoma, Wash.

THE MARBLE DEPOSIT.

The extent of the marble deposit at this locality has been investigated at a number of points on the surface by open cuts and trenches and in depth by 18 drill holes, and at all these places marble usually of good quality is exposed. As above noted, the marble belt is approximately 3,000 feet in width, striking in a northwesterly direction and dipping to the southwest. It is limited on the northeast side by an intrusive granite mass and on the southwest by the shore line. To the south it crosses the entrance to Dry Pass, but just back of Shakan it is cut off by a granite mass. To the northwest it extends into the channel and reappears at the entrance to Calder Bay, extending northward and overlying beds of conglomerate. Along the shore exposures and at the quarry small dikes of diabase, striking northeastward and much altered and faulted, were observed intersecting the marble beds. Apparently these dikes antedate the metamorphism of the limestone and therefore the intrusion of the granite. They are, however, but a foot or two in width and not sufficiently numerous to affect the value or expense of quarrying the marble. In the present opening at the quarry only one dike is exposed. Both surface cracks and slipping planes are present in the surface exposures of the marble, but in depth these are less numerous and will not materially interfere with quarrying.

Three distinct varieties of marble are found—pure white, blue veined with white background, and light blue much of which has a mottled appearance. The pure white, which has a finely crystalline texture, is the most valuable. All of the marble is free from the silica and flint beds common in most quarries, and though thin seams of pyrite were observed, they do not occur in a quantity detrimental to the stone. The following is a chemical analysis of the white marble made by E. F. Ladd for the Alaska Marble Company:

Chemical analysis of white marble from Marble Creek, Prince of Wales Island, Alaska.

Insoluble matter	None.
Oxide of iron (Fe_2O_3)	Slight trace.
Sulphuric anhydride (SO_3)	Trace.
Lime (CaO)	55.59
Magnesia (MgO)	.30
Carbon dioxide (CO_2)	43.67
Undetermined	.44
	100.00
Calcium carbonate ($CaCO_3$)	99.26

A qualitative test for magnesia in a sample collected by the writer was made by George Steiger, of the United States Geological Survey, who reports a content of less than 1 per cent.

To determine the crushing strength of the stone the Alaska Marble Company submitted samples to N. H. Winchell, State geologist of Minnesota, who reports an average strength of 10,521 pounds per square inch—a strength ample for all building purposes. Though not equal to the best Italian grades, this marble is better than most American marbles, and in the market will compete on at least equal terms with the product of Vermont, Georgia, and Tennessee.

METHOD OF QUARRYING.

At the quarry it was first necessary to remove the uppermost layers of the more or less fractured marble. This was done by channeling machines, a method which is preferable to blasting, as it does not injure the massive rock in depth. The machine used is mounted with a donkey engine on a truck and cuts a channel 2 inches in width at a rate of 7 to 8 square feet per hour. These channels are extended to a depth of 4 feet and are made at intervals of 4 or 6 feet in one direction and at intervals of 6 feet at right angles, so as to form blocks 4 to 6 feet by 6 feet in surface area and 4 feet in depth. These blocks are undercut by gadding machines, in which a drill is set so as to drill a series of holes under the block, and in these holes wedges are driven and the block is freed from its base. It is then lifted by a derrick to the car on which it is carried to the wharf. The blocks contain from 96 to 144 cubic feet of marble and weigh from 7½ to 11 tons each, the dimensions depending on the handling capacity of the machinery. The larger portion of the marble product is shipped in the rough state to a sawing and polishing plant at Tacoma, where it is prepared for the market. Small shipments have also been made to Chicago, Milwaukee, St. Louis, Cincinnati, and other points for trial tests.

EL CAPITAN MARBLE COMPANY.

The property of the El Capitan Marble Company is situated on the eastern side of a low mountain range 5 miles due east of the Alaska Marble Company's quarry and on the north side of Dry Pass. These locations, including 10 claims, were first made in 1901 and were sold to the El Capitan Marble Company in 1903. Except for a small amount of assessment work, operations were not begun until April, 1904. During that year a quarry consisting of a pit 12 feet deep was opened on a marble deposit close to tide water, a channeling and gadding machine was installed, and a cutting plant operated by steam power was erected. Some marble was quarried and shipped to Seattle at the close of the year, but since that time operations have been suspended.

The marble deposit flanks the eastern side of the granite mass represented on the geologic map (Pl. II) and from its relative position and general character is similar to the Marble Creek deposit farther west. The marble belt is exposed at tide water and forms high bluffs at 200 to 400 feet elevation one-fourth of a mile back from the shore. In these bluffs it has been prospected by trenches and open cuts. A number of diabase dikes crosscut the marble beds. The dikes are faulted and show in many places several feet of displacement, though this faulting, as well as the intrusion of the dikes, probably occurred previous to the metamorphism of the original limestone beds, as no trace of the fault planes could be seen, and the dikes themselves were much altered and sheared. The marble as exposed in the quarry is not of so good quality as that from the Marble Creek property, being less firm and more coarsely crystalline. Surface cracks and fracture planes are present in the surface exposures, but in the bottom of the pit these features are less pronounced.

AMERICAN CORAL MARBLE COMPANY.

The properties of the American Coral Marble Company are at two localities—(1) at the head of North Arm, where 12 claims have been located along the north shore of the inlet, and (2) at the north entrance to Johnson Inlet, where the company has several claims extending from Dolomi eastward to Clarence Strait. The principal developments have been made at the North Arm property, and at this point a post-office named Baldwin has been established. Active work at this locality began in 1904, and the marble deposits were prospected during that year. In 1905 a wharf was built, machinery was installed, and buildings were erected preparatory to quarrying the marble. During 1906, however, practically no work was done, and all the machinery was removed in 1907. At the Dolomi property a small quarry was started on the hillside, at a point a quarter of a mile northeast of Dolomi post-office and a few hundred feet from tide water on the Clarence Strait side, where buildings were erected. No operations were in progress at these localities during 1907.

The deposits at North Arm and Dolomi consist of marble beds interstratified with chloritic and calcareous schists, striking northwest with steep dips, usually to the southwest. The surrounding area is mantled by a dense growth of vegetation, and the limits of the deposits have not been definitely determined, though where the marble is exposed it is much fractured, variable in color and composition, and intersected by a few narrow dikes of diabase. The fracture planes were probably formed principally during the period of tilting and folding of the beds and existed before erosion exposed the present surface outcrops. Since that time weathering has accentuated and to some extent increased the number of fracture planes. It seems probable, however, that in depth these planes, although potentially present as lines of weakness, will become less numerous and will not interfere greatly in quarrying.

Although some parts of the deposits consist of pure-white, fine-grained marble of excellent quality, other parts are poorly colored, coarse grained, and of little commercial value, and it will probably be difficult to obtain large quantities of uniform grade. The better grade is reported to give the following analysis: Calcium carbonate, 94 per cent; alumina, 3.9 per cent; silica, 1.4 per cent; magnesia, 0.7 per cent. Pyrite is also present in small amounts, occurring in thin seams and finely disseminated in some of the marble.

MARBLE ISLAND.

Marble Island, a low wooded area of 9 square miles, is one of the larger islands in Davidson Inlet and lies 10 miles due south of Shakan, though by water it is nearly 30 miles distant. On the northwest side of this island marble was first discovered in 1899, and in 1903 a number of claims were located over this portion of the island and a small amount of stripping was done. Samples of this marble were quarried for test purposes and several varieties of good quality obtained. The total developments have not exceeded the assessment requirements.

The marble deposit is exposed in a cove on the northwest side of the island, and half a mile from the shore, at an elevation of 100 feet, it has been worked by an open cut. A considerable area is underlain by marble, though little is known of its extent or value. Along the eastern shore of the island an area of granitic intrusive rock was noted.

REVILLAGIGEDO ISLAND.

A well-defined limestone belt traverses the eastern portion of Revillagigedo Island in a northwesterly direction and is exposed in Thorne Arm, Carroll Inlet, and George Inlet. Its widest development is on the north side of George Inlet near the head, where marble claims known as the Bawden group were located in 1904. The deposit is included in the crystalline schist near the contact with the less altered slates to the southwest. The marble beds range from 10 to 20 feet in width and are separated by strata of calcareous schist. Their strike is northwest, with northeasterly dip. The marble is exposed in cliffs near tidewater and is of good quality, being relatively free from fracture and joint cracks, finely crystalline, and from white to gray in color. No large developments have been started on this property.

In Carroll Inlet to the southeast claims have also been located on the same belt, but at this locality the deposit is not so extensive as in George Inlet.

HAM ISLAND.

Ham Island lies at the junction of Blake Channel and Bradfield Canal, 25 miles southeast of Wrangell. It is about a mile and a half wide and consists largely of crystalline limestones with interstratified beds of calcareous schist striking N. 35° W. and dipping 75° NE. Intrusive dikes of basalt are common, and across the narrow channel on the mainland and on Wrangell Island wide belts of granite intrude these limestone and schist beds and have probably induced the present crystalline texture in the limestone and thus formed the marble.

Two distinct varieties of marble are found—one fine grained and pure white, the other very coarse grained and pale blue. Several systems of jointing planes traverse the deposits, but the joints are widely separated and will not interfere greatly in quarrying. Checks or surface cracks are practically absent and wide areas of massive marble have been found directly underneath the soil. Much of the marble appears to be free from impurities.

Two groups of claims have been located on this island, the Woodbridge-Lowery group on the west side and the Miller group on the east side. On the former the marble quarried is principally of a white, finely crystalline variety, but at the Miller property the deposit, exposed in a bluff 40 feet high and 100 feet long, is of a coarsely crystalline texture and a bluish color. On both of these properties considerable exploratory work has been done, and large blocks of the marble have been quarried, from which tombstones and small blocks have been chiseled and polished for local use. The properties are favorably located both for quarrying and transportation.

ADMIRALTY ISLAND.

Marble is known to occur at several localities on Admiralty Island, namely, at Marble Bluffs, on the west coast; at Square Cove, just north of Marble Bluffs; and in Hood and Chiak bays, south of Killisnoo. At these points some of the marble is of good quality, but most of the deposits contain silica and pyrite and the rock is not of much value. The deposits at Marble Bluffs are apparently more extensive and of better grade than those at the other localities.

GRANITE.

DISTRIBUTION.

The granitic intrusive rocks occupy about one-half of the aggregate land area of southeastern Alaska. In composition they range from granite to granodiorite or to quartz or hornblende diorite. The core of the Coast Range, as well as the central portion of many of the islands, is composed of this intrusive rock. The metamorphism in the granite, its nonuniformity in color, and the presence of joint cracks, so far as observed, make most of the stone undesirable for building purposes. However, granite masses of good quality, uniform in color and favorably located for purposes of quarrying, were observed along the mainland up Portland Canal, in Behm Canal, at Thomas Bay, in Taku Inlet, and at the head of Lynn Canal. On the islands numerous granite stocks occur, portions of which are of massive and uniform texture, though these stocks contain numerous segregations of the femic minerals, and pyrite is present in many places, rendering the rock less desirable for building purposes. Rock of good quality was observed at Gut Bay and Whale Bay, on the coast of Baranof Island.

All the granite masses in this region are similar in composition, having plagioclase feldspar as an essential constituent. Hornblende is the usual dark mineral, though biotite mica is present in much of the rock and in a few places exceeds in amount the hornblende. Quartz is commonly present, though usually in small amounts. The accessory components are apatite, titanite, and magnetite; secondary minerals, due to general metamorphism, are sericite, epidote, zoisite, chlorite, and calcite. Petrographically much of the rock is related more closely to the diorites than to the granites and is usually referred to as a diorite.

The prevailing color is light gray and in only a few places were pink or reddish masses observed. The grains of the component minerals are ordinarily of medium size, not varying greatly in the different localities. Evidence of the durability of the granite is afforded in many places where long exposure to the influence of weathering has caused little or no disintegration of the surface.

MARKET.

No attempt has yet been made to quarry or even to investigate the Alaskan granite. There is practically no market in Alaska for the stone, and along the Pacific coast to the south the demand has been supplied by the quarries in the States of Washington, Oregon, and California.

The long haul necessary to reach the market appears at first unfavorable to granite quarrying along this portion of the northwest coast, but the present freight rate of less than $3 per ton to Puget Sound is not greater than the cost of transportation from some of the quarries in California to the larger cities. The cost of quarrying the stone in the Western States is estimated at 35 cents per cubic foot, and the proportion of marketable rock obtained from the amount quarried is about 60 per cent. The average selling price per cubic foot for building purposes at the quarries in the coast States in 1906 was as follows: Rough, $0.85; dressed, $2.35; for curbing, $1. For monumental purposes the stone sold for $1 to $2 per cubic foot rough and for $3 to $6 dressed. These prices do not include the cost of transportation from the quarries to the cities, which is from 50 cents to $3 per ton. This adds from 5 to 30 cents to the cost of the stone per cubic foot.

GYPSUM.

THE GYPSUM DEPOSIT.

The only extensive deposit of gypsum known in southeastern Alaska is situated on Gypsum Creek a mile from its mouth, at Iyoukeen Cove, on the east side of Chichagof Island. The gypsum beds apparently overlie the Carboniferous rocks exposed along the southwestern shore of Iyoukeen Cove and forming the ridge southwest of Gypsum Creek, though the area of contact is buried under deep gravel deposits along the beach and in the valley. The mountain ridge to the northeast is made up of a granitic mass intruding the older limestone and quartzite. Structurally the gypsum beds are folded and steeply tilted and were probably laid down previous to the granitic invasion. They are at present regarded as of Permian or Triassic age.

The geology in the immediate vicinity of the gypsum beds is obscure and neither foot wall nor hanging wall of the deposit is exposed. Bluffs of a cherty limestone striking northwest and dipping to the northeast are exposed near the entrance to the tunnel at the lower mine workings on Gypsum Creek. The gypsum beds in the tunnel and lower levels have an east-west to N. 70° E. strike, with a northerly dip of 20° to 60°. Channels representing old watercourses and now filled with gravel wash are numerous throughout this deposit. These gravels resemble unconsolidated conglomerate beds and have been mistaken for both hanging and foot walls of the gypsum beds at points in the workings. A careful inspection of the gravels shows that the wash has the same character as that now in the creek bed. Of significance is the presence of cobbles of granite corresponding to the intrusive mass at the head of the creek, which invaded the area subsequent to the deposition of the gypsum beds.

MINE DEVELOPMENTS.

This gypsum deposit, the property of the Pacific Coast Gypsum Company, has been extensively developed during the last few years and large shipments of the rock are being made to the plaster mill at Tacoma, Wash., where it is prepared for the market. The developments consist of a wharf 2,000 feet in length extending to deep water, where rock bins of 1,000 tons capacity have been built, and of a railroad about a mile in length to the mine workings. At the mine rock bins of 1,500 tons capacity have been erected, thus affording sufficient storage capacity during intervals of transportation of the gypsum to the plaster mill. A vertical shaft has been sunk for 190 feet and from it two levels have been extended at points 90 and 160 feet in depth, both of which are almost entirely in gypsum. The main developments are on the 160-foot level and include 1,200 feet of workings, exposing the gypsum bed over an area 450 by 225 feet. Both the thickness and the lateral extent of the bed are still undetermined. At a point 800 feet west of the shaft investigations were made in former years of a gypsum exposure on the creek bank, where a short tunnel was driven and a 75-foot shaft sunk almost entirely in gypsum, but work at this point was discontinued.

MARKET.

Gypsum is in much demand along the Pacific coast as wall plaster and fertilizer and in the manufacture of cement. The Puget Sound market is supplied in large measure from the deposits in Kansas, Colorado, Wyoming, and Utah. The California market is supplied from local deposits and those in Nevada and Utah. Transportation from these points to the seaboard cities costs from $4 to $7 per ton, and the present market prices of first-grade gypsum products in these cities are as follows: Crude, $5 to $7 per ton; land plaster, $6 to $8 per ton; plaster of Paris, $8 to $11 per ton; wall plaster, $9 to $12 per ton.

CEMENT.

There are several kinds of cement, the principal kinds being Portland cement and natural cement. Portland cement is produced by burning a finely ground artificial mixture containing essentially lime, silica, and alumina in certain definite proportions. Usually this combination is made by mixing limestone or marl with clay or shale; such a mixture should contain about three parts of the carbonate to one part of clayey material. Natural cement is the product of an impure limestone containing from 15 to 40 per cent of silica, alumina, and iron oxide. Calcareous and argillaceous rocks suitable for cement making are relatively scarce in the Ketchikan and

Wrangell districts. They are metamorphosed, usually containing mica and some pyrite, and are not sufficiently fine grained to be of value. At only one locality—Long Island in Kasaan Bay—have rocks of this sort been located for the manufacture of cement. Here beds of limestone and siliceous shale are exposed around the shores of the island and are apparently of a quality suitable to make cement. The disposition of this product will, however, be confined to the local market, as it can not now be profitably shipped to compete with the cement manufactured along the Pacific coast. The reason for this, in the first place, is the high cost of the fuel necessary for its manufacture. The difficulty in obtaining efficient and cheap labor, as compared with the labor of the Puget Sound area and California, must also be considered, and the long haul necessary to reach the market is unfavorable to such an industry. To ship the cement rock as mined to a cement factory established somewhere near the point of coal supply and near the market would be the most feasible plan; but this would bring little or no profit, as vast areas of cement rock are exposed near all the larger cities and can supply the cement plants along the coast for many years to come.

CLAY.

Large deposits of clay are known to occur at the head of Vallenar Bay and along the banks and deltas of many of the glacial streams. These clays are fine grained to gritty, bluish in color, and semiplastic, and are usually termed "glacial mud." They are especially suitable for the manufacture of brick. For cement making the clay would require the addition of limestone and fine grinding, as coarse particles are scattered through it. The clay deposits are of only local value, and the material has little or no commercial importance.

THE MINERAL RESOURCES OF THE KOTSINA AND CHITINA VALLEYS, COPPER RIVER REGION.

By Fred H. Moffit and A. G. Maddren.

INTRODUCTION.

The four best-known and most promising copper-bearing regions of Alaska are the Kasaan Peninsula region of southeastern Alaska, the Prince William Sound region, the region included within the drainage area of Kotsina and Chitina rivers, and the region of upper Copper, Tanana, and White rivers. Of these four only Kasaan Peninsula and Prince William Sound have yet produced copper commercially and at the present time they furnish the entire production of Alaska, which in 1906 amounted to 8,685,646 pounds of blister copper—an increase of more than 3,500,000 pounds over the output of the previous year.[a]

The mines of these two regions are all located either at tide water or within comparatively easy reach of it, so that the matter of transportation does not present so great an obstacle to development as in the interior of Alaska, and they thus possess an advantage that has enabled them to reach the productive stage more rapidly than otherwise would have been possible.

The two remaining regions, each of which is sometimes referred to as the Copper River region, although the name is more often applied to the Kotsina-Chitina area (Pl. III), are really one, but are distinguished from each other because they lie on opposite sides of an almost impassable mountain range. They are situated in the interior, north of the high mountains forming the Coast Range, and can be reached only by long, hard journeys over trails which, although their value to the prospector and traveler can hardly be overestimated, still leave much to be desired. The cost of supplies and the time and labor required to carry them into the country have been so great that little more than the assessment work required to hold claims or to obtain patents has been done. The whole of the interior region may be said to be still in the prospecting stage and must remain so until means are provided by which supplies and equipment can be brought to it more cheaply and by which the ore, when produced, can be taken out.

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[a] Graton, L. C., The production of copper in 1906; Mineral Resources U. S. for 1906, U. S. Geol. Survey, 1907.

The first study of the copper deposits of Chitina Valley by members of the Geological Survey was made by F. C. Schrader and A. C. Spencer[a] in 1900. At the same time a topographic map of the region, including Hanagita Valley on the south and lower Copper River as well, was made by T. G. Gerdine and D. C. Witherspoon. Prospecting was then just beginning and very little work had been done on any of the claims, yet some of the important facts concerning the ores were established. Two years later (1902) W. C. Mendenhall[b] visited the west end of the area, including Kotsina River and Elliott Creek, but after that time no further work in the region was undertaken by the Survey till 1907, when public interest made it desirable to send another party into the field.

In this paper, which embodies the principal results of last season's work, the copper deposits of the Kotsina-Chitina region are described. Only enough of the general geology is introduced to give a clear idea of the relation existing between the copper ores and the rocks with which they are associated, as it is desired to lay emphasis on the economic side of the subject and to avoid confusing this with descriptions of formations and their relations that may more properly be taken up in another place. It is hoped that the facts observed are here presented impartially and in such a way as to give a proper idea of the type of ores occurring in this region and of the progress in developing them since they were last visited by members of the Survey.

Those seeking information in regard to the commercial value of the deposits here described may be disappointed in finding no definite statements in regard to values. It has become the established practice in the Alaskan investigations not to treat this subject, for it evidently falls within the province of the mining engineer who investigates a particular property. In the short time available for their study it would obviously be impossible for the Survey geologists to sample the deposits visited, and it also appears unwise to publish the results of assays furnished by property owners, because it is not always possible to learn how a given sample was taken.

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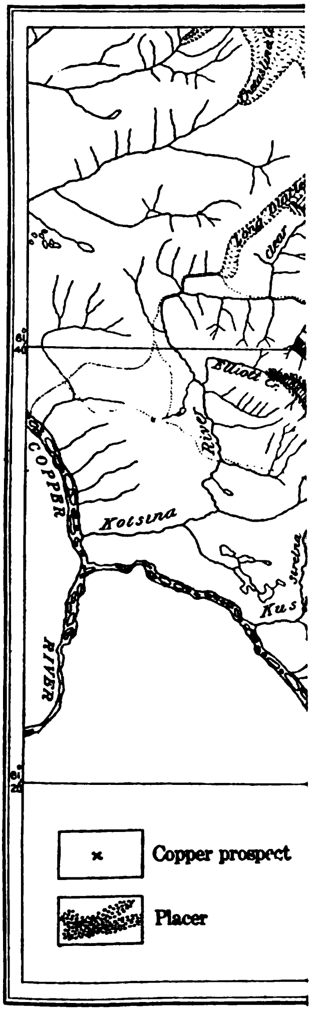
[a] The geology and mineral resources of a portion of the Copper River district, Alaska, a special publication of the U. S. Geol. Survey, 1901.

[b] Geology of the central Copper River region, Alaska; Prof. Paper U. S. Geol. Survey No. 41, 1905.

U. S. GEOLOGICAL SURVEY



GENERAL DESCRIPTION.

LOCATION.

The principal copper deposits to be described in this paper lie east of Copper River, within an area included between the watershed of the Wrangell Mountains on the north and Chitina River on the south and extending eastward from Kotsina River and Long Glacier to the meridian passing through Skolai Pass, a distance of approximately 75 miles. (See Pl. III.) This description, however, gives an exaggerated idea of the extent of the copper-bearing rocks, which, although they are found from one end to the other of the area indicated, occupy but a small part of the whole. Geographically this area crosses diagonally, from northwest to southeast, the quadrangle bounded by meridians 140° 20′ and 144° 20′ west longitude and parallels 61° 10′ and 61° 50′ north latitude.

TRAILS AND TRANSPORTATION.

The region is reached by a trail from Valdez, the distance from Valdez to Kotsina River being not far from 125 miles. In summer the Government trail via Tonsina is used, but in winter supplies have in some years been taken in by way of Tasnuna and Copper rivers. The ice on Copper River furnishes excellent sledding and it is possible to haul very heavy loads over it, but the violent winds that sweep down the Tasnuna and Copper valleys often prevent traveling for days at a time.

In summer Copper River is crossed by boats. An Indian named Billum has a ferry license and transfers travelers with their equipment in two small boats at a place about 1½ miles above the mouth of Tonsina River, called Copper River Crossing. There is a road house here on the west side of the river. Horses swim the river, but this is a somewhat dangerous undertaking because of swift currents and quicksand, and it is not an uncommon thing for one to be lost.

Travelers for Kotsina and Chitina rivers follow the same trail eastward from Copper River Crossing for 8 miles to Horse Creek, where the trail divides, one branch going northeastward to Willow Creek and the upper Kotsina, the other southeastward up the Chitina Valley. From Willow Creek the northerly trail follows the right (west and north) bank of Kotsina River and crosses the lower end of Long Glacier. There is a bridge over Kluvesna Creek and another over Kotsina River near the mouth of Rock Creek, so that it is not necessary to ford these streams. The Hubbard-Elliott Company has built a bridge over Kotsina at the mouth of Willow Creek, on the trail to Elliott Creek. A bridge was recently built by the Government over Kotsina River at the point where the lower or Chitina trail crosses it, doing away with a dangerous ford at that place. From the Government bridge the trail continues eastward along the foothills of the Wrangell Mountains, crossing Kuskulana River 3 miles below the glacier and reaching the head of Chokosna River and the Lakina by way of Kuskulana Pass. Ascending Fohlin Creek, it leads through Kennicott Pass and down Fourth of July Creek to Kennicott Glacier and Kennicott River, which is crossed on the glacier ice. A good trail leads to the Bonanza property from the lower end of the glacier. Another trail follows McCarthy Creek for 4 miles and, crossing the ridge known as Sourdough Hill, extends to Nizina River, from which Chititu Creek, Dan Creek, and Chitistone River are easily reached. Nizina River must be forded—a task that may be difficult, if the water chances to be high. There are no bridges east of Kotsina River, and most of the streams, being of glacial origin, are very cold, but the only ones likely to cause trouble are the Kuskulana, Lakina, and Nizina.

It is a common thing for prospectors in the Nizina country to come out in the fall by way of Chitina and Copper rivers, either leaving the Copper at Tasnuna River and going overland to Valdez, or following the river to the coast and landing at Eyak or Orca. Several days' work is needed to whipsaw the lumber and build the boat, but the river trip is even then much quicker and easier than the overland trail. The distance from the mouth of Young Creek to Tasnuna River, over 115 miles, has been made in less than twenty running hours. A skillful boatman would meet with little or no difficulty on the Copper or Chitina, but the canyon at the lower end of Nizina River is dangerous, particularly at low water, and a number of persons have been drowned in trying to run through it.

In July, 1907, a small steamboat called the *Chitina* made her first run from Tasnuna River to Copper Center on Copper River and to the mouth of Nizina River on Chitina River. The material for her construction was hauled over the snow from Valdez during the previous winter, and she was completed early in July, but after the trip up the river was hauled out on the bank for the winter. She draws very little water, but will probably be unable to run after the middle of summer because the river is much lower in the fall than during spring and early summer. Boats can not descend Copper River farther than Abercrombie Rapids, 25 miles below Tasnuna River, and any freight the *Chitina* may carry up the river must be delivered to her either at the rapids or at Tasnuna River.

The building of a railroad from a point on the coast to the interior Copper River country is of prime importance in the development of the copper resources of the region. During the last few years various companies have been formed with this object in view, and railroad surveys have been made from Katalla, from Orca, and from Valdez by both the Tasnuna and the Tonsina routes. Construction work has been done in all these routes, but, except the Copper River and Northwestern Railroad and the Alaska Pacific Railway and Terminal Company, none of the companies were making progress last summer, although the Alaska Home Railway laid a few miles of track at Valdez.

The Copper River and Northwestern Railroad has its coast terminal 28 miles west of Copper River on the east side of Prince William Sound at Eyak, or Cordova Bay, as it is frequently called. The terminal was changed from Katalla to Eyak late last fall, probably because of the great difficulty experienced in lightering freight at Katalla and the expense and time that would be required in building a breakwater for the protection of ships while discharging cargoes. Eyak has a protected harbor and can be approached at any time. A wharf and a few miles of railroad embankment from Eyak village to Glacier River had already been constructed by another company, but were purchased by the Copper River and Northwestern. It is proposed to use the Katalla branch, which will join the main line in the vicinity of Childs Glacier, as a means of reaching the Controller Bay coal fields. Considerable work on this branch, originally intended as the main line, has been done at Katalla and in that vicinity. In October, 1907, construction trains were running between Katalla and Martin Point, a large part of the rock work along the coast from Martin Point to Softuk Bar was done, and most of the piling in the low ground on the east edge of Copper River delta as far north as Camp Seven, 7 miles from Palm Point, had been driven. Location surveys have been made up Copper, Chitina, and Nizina rivers to Kennicott River. Just how soon this railroad will reach the interior is difficult to say, in view of the progress during the last two years.

The Alaska Pacific Railway and Terminal Company starts from the coast at Katalla and contests the right of way through Abercrombie Canyon with the Copper River and Northwestern Railroad. In 1907 a trestle connecting Martin Point with the nearest of the Martin Islands was built, and when filled in with rock will be used as a breakwater behind which ships may be unloaded. Other work done by the company was directed largely toward the construction of a line to connect Katalla with the Bering River coal field.

The Alaska Home Railway is a railroad project started at Valdez in midsummer, 1907. This road was planned to connect Valdez with the Copper River region. It was to ascend Lowe River and reach the Copper River basin by way of Thompson Pass, whence it was expected to continue to Tonsina by practically the same route as the Government trail. Its motive power was to be electricity. A steam locomotive and some rails were shipped to Valdez, and a short stretch of track was laid, but work was soon suspended owing to lack of funds.

WORKING SEASON.

Inadequate and expensive transportation facilities have been the chief obstacle in developing the copper resources of Chitina River. Another adverse condition, which, however, affects prospecting more than it will mining, is the short summer season. Up to the present time practically all supplies have been taken in during the winter with sleds drawn by horses. In the earlier days dogs or man power were sometimes used, but of late years horses have been employed almost entirely. Sufficient feed to last till the grass starts in the spring is carried, but after that most horses "live on the country." The early snows begin about the end of August, so that a horse can not be expected to find his own feed longer than from about the first of June till the first of September. Grass is always abundant on the mountains near the timber line in June, July, and August, and good pasture is usually found at lower elevations after the timber has been burned off for a number of years. Some of the prospectors have provided their stock with fine feed by following this practice. In the timbered valley bottoms horses frequently have difficulty in finding enough to eat, even in midsummer, yet in the fall, after frost has killed the grass higher up, the river bars afford an excellent forage plant known as "pea vine," of which they are very fond. Since most prospectors use at least one or two horses for packing in summer, as well as for hauling supplies in winter, it is obvious that the matter of horse feed has an important influence in determining the number of available working days. The prospecting season is still further shortened owing to the fact that in the high mountains, where most of the copper ores have been found, snow often remains till the first or even the middle of July.

GENERAL GEOLOGY.

The major geologic features of the copper region may be briefly described as follows:

The geologic succession as determined by Schrader and Spencer, to confine the description to the rocks most closely associated with the copper prospects and gold placers, consists of four formations. These, named from the lowest to the uppermost, are the Nikolai greenstone, the Chitistone limestone, the Triassic shales, and the Kennicott formation. With these are associated igneous intrusives.

The basal formation of this succession—a slightly altered eruptive mass—is made up of a series of basaltic flows and is known as the Nikolai greenstone. It is conformably overlain by the Chitistone limestone, a massive limestone ranging in thickness from 200 feet on the Kotsina to 2,000 feet on Chitistone River and now known to be of Triassic age. Conformably overlying the Chitistone limestone is a succession of sedimentary beds whose lower part consists of banded limestone and shale, but whose upper part is made up almost entirely of shales. This limestone-shale series has a maximum thickness possibly greater than 4,000 feet and from fossil evidence is considered to be of Triassic age also. In places it was entirely removed by erosion before the deposition of the unconformably overlying Kennicott formation. Kennicott is the name applied to a body of rocks consisting of conglomerates, sandstones, limestones, and shales present in a few relatively small but widely distributed areas throughout the copper region. It is of Upper Jurassic or Lower Cretaceous age. These four formations and, more particularly, the lower three have been folded and extensively faulted. Some of the faults are of considerable displacement and horizontal extent, but readjustment, accompanying movements of the rocks, seems to have been brought about more by crushing and frequent faults of small displacement than by single movements of great amount.

In addition to the four formations thus briefly described, some small areas of coal-bearing rocks and the Pleistocene gravels should be mentioned. A thin bed of coal was seen not far west of the Kennicott Glacier, but a much greater amount is present near the head of Chitistone River. No fossils were collected from the coal-bearing rocks, but they are probably much younger than the Kennicott formation. Extensive Pleistocene gravel deposits occur along Chitina and Nizina rivers and extend into the valleys of their larger tributaries. Except on Dan and Chititu creeks they have nowhere proved of economic importance.

Igneous rocks other than the Nikolai greenstone are only locally abundant, but are found throughout the Chitina region. They include gabbro, diorite, porphyritic intrusives, and Tertiary volcanics. Of these the diorite and porphyritic intrusives are most closely associated with the copper-bearing rocks, and though of less areal extent, concern the present discussion more than the others. The largest diorite area is situated on the north side of Kotsina River near its head. It is surrounded by greenstone and has an areal extent of about 10 square miles. Dikes of the same material are found on the south side of the valley also. Light-colored porphyritic intruded rocks cut the Nikolai greenstone in a number of localities, but were not seen in the Chitistone limestone. They are most abundant in the Triassic shales of the eastern half of the copper belt and more particularly in the vicinity of Kennicott Glacier.

Because of the close and constant relation between the copper ores, on one hand, and the Nikolai greenstone and Chitistone limestone, on the other, it is necessary to give some further description of these two lower members of the rock series. The Nikolai greenstone, as mapped by Schrader and Spencer in 1900, includes a succession of basic lava flows of basaltic character, which, however, do not form a homogeneous whole, but show decided differences of texture and appearance in their vertical section. A flow or bedded structure is seen at many places and at first glance might suggest a sedimentary origin for the rock. This apparent bedding is much more evident in some localities than in others, and is most readily seen in the large cliffs which, in some places, constitute half a mountain side.

Directly beneath the limestone the Nikolai greenstone has much the same appearance wherever it was observed. It is a rough massive green rock whose individual crystals are generally too small to be distinguished by the naked eye. Lower down in the flow series the greenstone is usually found to be closer grained and denser, much of it with a fracture resembling that of quartzite. Amygdaloidal flows are numerous and the previously existing cavities are now filled with quartz or with dark minerals which in some specimens have been determined as chlorite and serpentine. Most of these flows are green in color, but a reddish hue is seen here and there, possibly the result of alteration or weathering. There is no evidence at hand to determine definitely the relation of the Nikolai greenstone to the more altered and probably older rocks occurring south of Chitina River, and so far as its age is concerned, we know only that it is older than the Chitistone limestone.

The Chitistone limestone is best developed in the vicinity of Chitistone River, where it attains its greatest thickness and is well exposed. Its outcrops, nearly always appearing as cliffs high up on the mountain, extend westward, however, all the way to Elliott Creek and Kotsina River and constitute one of the most conspicuous features of the topography. From a freshly broken fragment the color is seen to be bluish gray. A weathered surface, on the other hand, is light gray or dirty white, a fact which accounts in large measure for the striking appearance of the outcrops and in many places makes it possible to distinguish the limestone from associated rocks even at a long distance. Except where covered by talus from the limestone cliffs or by the unconformably overlying Kennicott formation, the contact of the Chitistone limestone and Nikolai greenstone can usually be traced without difficulty.

In the report of Schrader and Spencer the Chitistone limestone was tentatively correlated with limestone east of Skolai Pass, which at that time was considered to be of upper Carboniferous (now called Permian) age. Mendenhall, in a later paper, gave reasons for believing it to be still younger, probably Triassic, and his contention is established by fossil evidence collected last summer.

ECONOMIC GEOLOGY.

GENERAL OUTLINE.

The copper ores of the Chitina Valley are associated with the Nikolai greenstone and Chitistone limestone. In the western half of the copper-bearing area the copper minerals, with one exception, were seen only in the greenstone, and most of the prospects are at no great vertical distance below the limestone contact, yet this is not an invariable rule. In the eastern half of the area, on the other hand, the largest and most valuable copper deposits known are either at the limestone-greenstone contact or immediately above the contact, in the limestone. There are deposits of copper in the greenstone here also, similar to those farther west, but so far as they are now known they are of less importance than those associated with the contact.

A large number, perhaps a majority, of the copper prospects examined during the summer have a form which Mendenhall has described as "bunch deposits." This term, though an unsatisfactory one in some ways, probably describes as closely as any single term can the form of ore body most common in the Chitina Valley. A smaller number of the deposits occur as fairly well defined veins. The term "bunch deposit" does not necessarily refer to a mass of ore composed of copper minerals only, as most of the ore bodies to which the term could be applied are not such masses, but it does indicate that the length, breadth, and thickness of the body do not differ from one another greatly.

The copper minerals are chalcocite, bornite, chalcopyrite, native copper, and the oxidation products, malachite, azurite, and cuprite. The ores, as they appear on the surface, are chiefly chalcocite and bornite. Chalcopyrite is not as common as either of the other two sulphides, but forms an important part of the ore at several prospects. Native copper is present in the greenstone of all parts of the Chitina region and is surprisingly abundant in some of the stream gravels. Masses of several hundred pounds and one of more than 2 tons have been discovered. Wherever native copper was observed, it is associated with amygdaloid beds of the greenstone and consequently is some little distance below the limestone. More extended observation, however, might show that this is not always the case.

No considerable bodies of oxidized ores have been found in the Chitina region. Malachite and azurite, the green and blue carbonates, are merely surface alterations on the other copper minerals, and cuprite, the red oxide, is a common oxidation product. Azurite is the prevailing carbonate accompanying the copper sulphides associated with the heavy limestone or in veins with a calcite gangue. Malachite gives the green stain usually seen in the ores in greenstone.

The copper ore is composed in many places of country rock and copper minerals without any accompanying gangue. The copper sulphides fill fractures in the rock and also occur as a replacement of the rock. Where the country rock is greenstone, a careful examination is usually necessary to determine the limits of the impregnation, which is not marked by any definite boundary, the replacement becoming gradually less with increasing distance from the center of impregnation. In limestone areas, on the other hand, the transition from copper sulphides is abrupt and the bounding surface is more readily determined.

Faulting, as has already been pointed out, is a phenomenon observed at many localities in the rocks of the Wrangell Mountains. Zones of crushing and shearing show the same result as has been accomplished at other places by fault movements, the disturbing forces that produced them having led to a circulation of mineral-bearing waters through the rock. Most of the channels were exceedingly variable in form and direction, and this fact explains the rarity of definite, regularly formed, and clear-cut veins in the region. This is particularly evident from an examination of the ores in greenstone. Where the more regular vein deposits occur they are usually connected with fault planes and some of them are accompanied by other minerals, as calcite and quartz. Calcite is nearly always the predominating gangue mineral where such minerals are present, and is particularly prominent near the limestone-greenstone contact. The basic greenstone could furnish only a small amount of quartz to circulating waters, but calcite was supplied abundantly from the overlying limestone. The wide distribution of copper minerals in the Nikolai greenstone wherever it occurs has led to the belief that the greenstone itself is the source from which the copper was derived and that the ore deposits as they now exist have resulted from the concentration of copper minerals disseminated in small quantity through the rock.

Copper prospecting in the Chitina region is carried on from a few central localities, of which those receiving most attention are Kotsina River (including Elliott Creek), Kuskulana River, Kennicott River, and Chitistone River. These centers are named from west to east, the order in which they were visited, and the prospects will be described in the same way.

KOTSINA RIVER BASIN.

Kotsina River receives a large part of its water from snow fields and glaciers on the south slopes of Mount Wrangell and joins Copper River 2 miles above the Chitina. Much of the drainage area is occupied by Nikolai greenstone, but the limestone, shales, and conglomerate are all present. Prospecting is most actively carried on in the upper part of the basin and on Elliott Creek. The upper tributaries include Peacock Creek, Surprise Creek, Roaring Creek, Ames

Creek, Rock Creek, Kluvesna Creek, and Copper Creek. No work has been done here which can properly be called mine development, as there is no place where sufficient work has been done to demonstrate the presence of a mine.

KOTSINA RIVER.

Practically the only prospecting on the Kotsina itself is that done by the Great Northern Development Company. This company is the largest one carrying on operations on the Kotsina, to which, however, its interests are not confined. The headquarters of the company are on Kotsina River at the mouth of Roaring Creek, and its equipment includes a sawmill and telephone connection with the Government telegraph line at Tonsina. Probably 100 men were employed during the summer. The prospects on the river include five short tunnels, the nearest one of which is about one-half mile below the camp. They are within a short distance of one another on the south side of the river and almost on the same level as its broad gravel floor. No one of these tunnels had been driven farther than 20 feet in August, 1907. At the first a porphyritic dike 10 feet thick cuts a fine-grained greenstone. Its course is N. 30° W. and it is bounded on both sides by fault planes. A little copper-bearing pyrite was deposited along the faults in the fractured rock. At the second tunnel, a few hundred feet to the west, a quartz vein ranging from 4 to 6 inches in thickness contained a little copper pyrite. The vein has a strike S. 50° W. and cuts the greenstone in a perpendicular direction. At the other three tunnels a little pyrite is present in the greenstone. Its oxidation gave the brown stain by which the tunnels were located.

AMES CREEK.

Ames Creek is the first creek below Roaring Creek on the south side of Kotsina River. It is a small creek in a hanging valley and, like nearly all the tributaries of this river, owes the broad, round cross section of its valley to the work of glacial ice. The copper prospects include three tunnels, the property of the Great Northern Development Company, known as tunnels 6, 7, and 8.

Tunnel 6 is on the west side of Ames Creek and is at an elevation of 1,400 feet above its mouth. Early in August, 1907, it had been driven for 50 feet in a southwesterly direction in frozen slide rock from the hill above. Country rock in place had not been reached. One hundred feet above the tunnel a little pyrite is seen in a dense, hard, faulted greenstone.

On the east side of Ames Creek, and 50 feet higher than tunnel 6, is tunnel 7, which runs N. 30° E. for 70 feet through loose slide rock before reaching the undisturbed greenstone, which here is fine grained and stained with iron from the oxidation of pyrite.

Tunnel 8 is also on the east side of Ames Creek, one-fourth mile south of tunnel 7. It had been driven for 30 feet in amygdaloidal greenstone, but no copper had been found.

ROCK CREEK.

Rock Creek is one of the largest southern branches of the Kotsina and heads against Strelna and Nugget creeks, tributaries of Kuskulana River. A horse trail crosses the divide from Rock Creek to Strelna Creek and furnishes the shortest road from upper Kotsina River to the Chitina Valley. Active prospecting was confined to Lime Creek, a tributary of Rock Creek, which joins it from the east. The Warner prospect at the mouth of Rock Creek, which was visited and described by Mendenhall in 1902, is now patented and no further work has been done on it. Lime Creek flows near the limestone-greenstone contact, and the copper deposits, although mostly northeast of the creek on the opposite side from the southwestward-dipping limestone, are not far from it. The prospects are near the point where the Rock Creek trail crosses Lime Creek. In July, 1907, a tunnel was being driven in the greenstone just below the limestone, only a few feet above the creek, but no ore had been found at that time.

Several feet up the hill to the northeast was a tunnel 20 feet in depth, in jointed greenstone. The principal copper mineral is bornite, which occurs as lenses or irregular lumps in the greenstone, having diameters up to 1 inch or more. These patches, so far as the surface shows, appear to be unconnected. Bornite also fills fractures in the rock and forms small lenticular veins, but it appears principally in joint planes on whose surfaces it forms a veneer in places an eighth of an inch or more in thickness. There are small veins of calcite and quartz.

About 50 feet farther east is an open cut showing similar rock and ore, although here the ore is in greater amount. The bornite occurs in sheared greenstone cut by small faults striking N. 35° E. and dipping 60° S., and forms a lens-shaped mass 2 feet thick. The greenstone has nearly all been replaced by bornite.

At a point 200 feet still farther north and 100 feet higher is an open cut in amygdaloidal greenstone. The cavities are now filled with quartz or with a dark mineral, possibly chlorite. Several faults with gouge and zones of crushed rock up to 1 foot in thickness cut the greenstone with a strike of N. 15° E. and a dip ranging from 60° to 70° E. A little copper stain was seen along the crushed rock, but no other copper minerals, although bornite is found in the slide rock near by.

ROARING CREEK.

Roaring Creek is a southern tributary of Kotsina River, which it joins a short distance above the main camp. It heads in a small glacier and flows through an open valley several hundred feet higher than the level of the Kotsina. The country rock, with the exception of one small limestone area on top of the ridge between Roaring Creek and Peacock Creek, is greenstone, yet the greenstone is not of uniform character, for slaty beds and hard, fine-grained cherty-looking beds are intermingled with amygdaloidal flows. Most of the prospects are in the upper part of the valley.

The Great Northern Development Company has several prospects on Roaring Creek. One of these is located on the south side of a small gulch west of Roaring Creek, near the camp known as camp 3. A tunnel was started in gray and black mottled slates near a fault plane which separates them from the greenstone mass. The strike of the slate cleavage and of the fault plane is the same, N. 20° W., and the dip is high. The tunnel is perpendicular to the strike. There is some brown iron stain resulting from pyrite alteration, but no copper ore had been found.

Another tunnel was being started on the east side of Roaring Creek about half a mile above the tunnel just mentioned, but not enough work had been done to show the presence of ore. A piece of greenstone picked up near this place contained small particles of native copper.

Above camp 3 on the west side of Roaring Creek a tunnel 50 feet long had been driven by the California-Alaska Mining and Development Company. This tunnel is 2,600 feet above the mouth of Roaring Creek and at least 1,500 feet above camp 3. The country rock is greenstone and the ore consists of small calcite-quartz veins containing native copper and azurite. In a little gulch a few feet north of this tunnel, but some distance below it, a nugget of native copper, which from measurements was estimated to weigh between 500 and 600 pounds, was found in the slide rock.

The Kotsina Mining Company holds several claims on Roaring Creek. Among them is the Sky Scraper claim, located near the small limestone area previously mentioned. Several open cuts and short tunnels have been made and in July, 1907, the company was starting a tunnel on an exposure of copper minerals 350 feet below the base of the limestone at the north end of the area. This cut exposed a lenticular mass of chalcocite 6 inches thick and 3 feet long, as seen on the face, lying horizontally in the rough, coarse-grained greenstone that occurs immediately below the Chitistone limestone. In the vicinity there are several greenstone exposures in which chalcocite forms small patches or lenses. They are seemingly in no way related to one another.

PEACOCK CREEK.

Peacock Creek joins Kotsina River about 2 miles below the more southerly of the several large glaciers from which the river receives its water supply. There are two branches of the stream, one extending toward the east and the other toward the southeast. The eastern branch originates in a small glacier and the valleys of both branches were formerly occupied by glaciers. Greenstone is the country rock, with the exception of the limestone mass on the ridge between Roaring Creek and the more southerly branch of Peacock Creek. Dikes of diorite cut the greenstone, probably apophyses of the diorite mass on the north side of Kotsina River. The copper prospects of Peacock Creek are owned by the Alaska Kotsina Copper Company.

Rose claim.—The Rose claim is located on the point of the ridge between the two branches of Peacock Creek. It is a little more than 2,000 feet above the valley of Kotsina River. The greenstone is cut by a perpendicular fault striking N. 25° E. This fault is easily traced for a distance of nearly 400 feet and is indicated by a zone of crushed greenstone with a maximum width of about 12 feet in which the copper minerals are seen. Bornite, glance, chalcopyrite, and a small amount of native copper, with malachite and a little red oxide as alteration products, comprise the minerals associated with the fault.

White Dog and Mint claims.—Two claims on the west side of the more southerly fork of Peacock Creek have been partly prospected. The first of these, called the White Dog, is approximately 2,500 feet above Kotsina River. The country rock is greenstone and is cut by a fault plane striking N. 40° E. and dipping steeply westward. A crushed zone of rock along the fault ranges from 3½ to 4½ feet in width. The walls are well defined and clay seams show where the principal movements have taken place. An open cut 25 feet long has been made in the crushed rock. Chalcopyrite or copper-bearing pyrite is scattered through the crushed rock and clay seams and has strongly colored them with iron oxide. Green copper carbonate occurs as a surface stain, but the bornite and glance were not seen here. The fault is plainly marked along the steep mountain side for several hundred feet.

Two hundred feet above the White Dog and a little to the north is a claim called the Mint. A small fault with a strike of N. 15° W. and a dip of 60° W. cuts a grayish greenstone having amygdaloidal phases. The rock adjacent to the fault is broken and crushed, giving a zone with a thickness of 6 inches to 1 foot, which besides the greenstone includes a little quartz and calcite accompanied by bornite and glance. Chalcopyrite was not observed, but a heavy stain of iron oxide would indicate that either this mineral or pyrite had formerly been present. There is a parallel fault 4 feet from this main fault, and both are cut perpendicularly by a third poorly defined fault having the same strike and carrying a little bornite. The main fault was traced for a distance of 500 feet.

Mountain claim.—The Mountain claim is one of several on the north side of the east fork of Peacock Creek. It is about 2,600 feet above Kotsina River and consequently is at a greater elevation than the other claims described. In August, 1907, almost no work had been done on it and only a few small stringers of copper sulphides were exposed.

SHOWER GULCH.

A small stream joining Kotsina River a short distance below the glacier in which its southern branch originates is called Shower Gulch, from the waterfall near its lower end. Native copper is found near this fall in the amygdaloidal greenstone that forms the country rock. Copper occurs as thin leaves or films in fractures of the greenstone and as grains and small slugs in the greenstone and in the seams of the amygdules. It is in places associated with secondary quartz, filling irregularly shaped veins or cavites. Several claims have been staked on Shower Gulch, but little prospecting has been done.

SURPRISE CREEK.

Surprise Creek is a northerly tributary of Kotsina River and heads in the high mountain southeast of the lower end of Kluvesna Glacier. Most of its bed is cut in the diorite mass previously referred to and in a rude way follows the contact between the diorite and the greenstone on the east. It has a small easterly tributary, Sunshine Creek, which lies mostly in the greenstones. Tin is reported to have been found in the diorite of Surprise Creek, but such specimens of the supposed tin-bearing rock as were examined contained no tin and no reliable assay tests of the rock are known to the writers. All the copper prospects are in the greenstone east of Surprise Creek. They are the property of the Alaska Kotsina Copper Company.

Laddie claim.—Between Surprise and Sunshine creeks is a steep gulch running down from the north. On the west side of this gulch and nearly 3,000 feet above Kotsina River is the Laddie claim. A very close grained grayish " greenstone " forms the country rock and is cut by a fault striking N. 20° to 30° E. and dipping about 45° NW. Along the fault is a zone of crushed country rock ranging in width from 2 to 3 feet, in which is a quartz vein 18 inches thick. Besides quartz there is a small amount of calcite. The vein carries glance accompanied by a little bornite and chalcopyrite. In places the percentage of copper minerals in the vein is high, but they are not distributed uniformly through it. A line of prospect holes extends along the vein for a distance of 200 feet.

Sheehan claim.—At the Sheehan claim, 200 feet higher than the Laddie and a little farther east around the mountain side, the greenstone is cut by a fault striking N. 45° E. and dipping 45° NW. This fault resembles the Laddie fault in being accompanied by a zone of crushed rock, but the zone is here somewhat wider, ranging from 3 to 4 feet. A small quartz vein is exposed in which the copper minerals are glance, bornite, and a little pyrite. The small veins of glance cutting the quartz are in places half an inch thick.

Hubbard claim.—About 300 feet east of the Sheehan claim and a little higher on the mountain the vein of the Hubbard claim is exposed in two open cuts The vein is almost perpendicular and strikes N. 40° E. In the more southerly open cut there is a vein of white quartz ranging in thickness from 4 to 8 feet and carrying the copper minerals glance, bornite, and pyrite, which are named in the order of their abundance. A strongly marked fault with 3 inches of clay seam defines the north wall of the vein. Eight feet from the vein on the southeast is a second vein or lens of quartz 10 inches thick and also carrying glance. Between the two veins is crushed greenstone. Nearly 200 feet to the northeast along the strike an open cut 40 feet long and 25 feet deep has been made across the vein. The fault is seen again along the north wall, but the single large quartz vein exposed in the other cut is here represented by many smaller veins of lenticular form up to 12 inches in thickness. Glance and bornite are the copper minerals. Nearly 1,000 feet farther northeast a well-marked fault with a zone of sheared greenstone crosses the ridge between Kotsina River and the Hubbard claim and is said to extend as far as the glacier from which this branch of the Kotsina springs. There is little doubt that this fault is the continuation of that crossing the Hubbard claim.

KLUVESNA CREEK.

Kluvesna Creek and its tributary, Fall Creek, are the only streams besides Surprise Creek coming into Kotsina River from the north on which any prospecting or assessment work was done last summer. Kluvesna Creek drains the main lobe of Kluvesna Glacier, and the smaller western fork known as Fall Creek originates in a minor lobe of the same ice mass coming down from the snow fields of Mount Wrangell. The valley floor is a broad gravel flat and was once occupied by glacier ice, which has since retreated to its present position 7 miles from the river's mouth. The country rock is greenstone except that the Chitistone limestone forms the top of the ridge west of the southern part of the river and descends to the Kotsina River valley near its junction with that of Kluvesna Creek. Dikes of light-colored eruptive rock, mostly dioritic in character, cut the greenstones locally.

On the east side of Kluvesna Glacier, nearly three-fourths of a mile from its south end, copper minerals have been found in the greenstone several hundred feet above the ice. Three open cuts show a light-colored rock—possibly altered greenstone—cut by irregularly branching quartz veins. The light-colored rock contains chalcocite and chalcopyrite scattered through it in specks rarely larger than a pin head. There are besides this small veins of chalcopyrite. The greenstone country rock locally contains small particles of chalcopyrite, a fact that may have some bearing on the origin of the richer copper-sulphide ores.

West or a little southwest of the mouth of Fall Creek and nearly 1,800 feet above it is a short tunnel, the property of the Kotsina Mining Company. This tunnel is on the north side of a small gulch running down to Kluvesna Creek and is located at the contact of a fine-grained greenstone and a grayish amygdaloidal greenstone. The contact is parallel with several prominent fault planes cutting the country rock, strikes N. 35° to 45° W., and dips 50° SW. The fine-grained greenstone is much shattered and requires timbering to make it stand in the tunnel. Native copper appears as small particles in the amygdaloidal greenstone, both in the apparently unaltered rock and in portions that have been partly leached. It is also associated with small quartz and calcite veins in the greenstone. At many places where native copper is found there is a little red copper oxide. Several pieces of native copper and quartz weighing 20 or 30 pounds were piled on the dump, but nothing like them was seen in the tunnel or in the open cut above the tunnel.

A number of small open cuts and short tunnels in which copper minerals were seen, on Fall Creek or its tributaries, were examined. These small branches flow into Fall Creek from the west within the lower 2 miles of its course. Less than half a mile from the mouth of the most northerly one there is a short tunnel on the south side of the stream driven along a north-south fault in amygdaloidal greenstone. The greenstone is crushed and contains small veins of quartz and calcite. A green stain of malachite appears on the surface, but within the crushed country rock both green and blue copper carbonates are found in a way that suggests them to be the alteration products of some earlier copper mineral deposited along the fault. Between the rock fragments along the fault there is in places a soft black carbonaceous filling with which the copper carbonates are mingled. Very little copper is exposed by the tunnel.

South of this creek on the second tributary a short tunnel about 6 feet under cover was made along a perpendicular north-south fault plane in amygdaloidal greenstone. This tunnel is only a few feet above the creek and on its north side. The greenstone is cut by many small light-colored, fine-grained porphyritic dikes containing abundant grains or crystals of quartz. A very little bornite is associated with quartz veins in the greenstone.

Up the hill to the south and 1,375 feet above the short tunnel just mentioned is another tunnel 40 feet long, also in amygdaloidal greenstone. Here too the perpendicular north-south faulting is to be seen and green copper stains appear on the surface of the fractured rock. The tunnel was driven to strike the supposed downward extension of an outcrop of greenstone containing native copper exposed on the ledge 25 feet above the tunnel and about that distance to the south, but had not yet reached it. Bornite and copper carbonates in small amount were seen in a number of shallow open cuts a short distance southeast of this tunnel.

COPPER CREEK.

Copper Creek is the most westerly tributary of Kotsina River on which prospecting was done last summer. It drains a portion of the ridge between Kotsina River and Elliott Creek and joins the Kotsina 2 miles below Kluvesna Creek. All four of the geologic formations already named are present in the upper part of the basin—the Nikolai greenstone, Chitistone limestone, Triassic shales, and Kennicott formation. Their relations, however, are not simply those due to folding, for extensive faulting has accompanied the folding.

There are two principal branches of Copper Creek, but the westerly branch also forks at a point about 2½ miles from Kotsina River. Near this fork the limestone-greenstone contact crosses the two branches in a northwest-southeast direction and good exposures of the limestone are found between the branches as well as on each side of them. The greenstone, however, is not exposed on the slope from the fork to the limestone outcrops between the branches.

The workings of the Mullen claim are between the branches, about 1,000 feet from the place where they separate and 275 feet above it. Three open cuts have been made along the foot of a limestone cliff. The strike of the limestone at this place is difficult to determine accurately but is nearly north and south. It dips 45° W. In the northernmost open cut, which is 20 feet long and 10 feet in depth from front to back, a fault plane parallels the bedding and forms the west wall of the cut. The limestone is much broken, particularly near the fault, forming a zone of broken rock with a maximum width of 3 feet. In places the limestone is almost completely replaced by bornite and chalcopyrite. The best ore forms a poorly defined vein ranging in thickness from 12 to 18 inches but does not outcrop on the surface. Azurite is more abundant than malachite where the copper minerals are oxidized, and in places the bornite is completely altered to azurite. Small calcite veins are numerous, especially in the brecciated rock near the fault, where the fragments have been cemented together with calcite. There are minor faults or joint planes in which a green copper stain is seen, but this appears to be derived from the copper of the main vein.

About 75 feet south is another open cut where the fault planes are not prominent but where the limestone is much jointed. Bornite occurs in isolated bunches in the limestone.

A large open cut and shallow pit have been made 75 feet still farther south. Several faults may be seen here, but the most prominent ones strike east and west and dip at a high angle to the south. The north-south faults are present but are not continuous for more than short distances. Patches of crushed rotten rock stained with iron oxide and copper carbonates lie adjacent to the faults and joints. There are also small masses of high-grade bornite replacing the limestone and forming bunch deposits in the country rock. These deposits were probably connected by the joints and faults with the channels carrying the mineral solutions, but this is not evident at the surface. A little chalcopyrite and both malachite and azurite are present with the bornite. Malachite is the surface stain, but below the surface azurite is the alteration product of the copper minerals. The bornite is cut by many thin veins of azurite and in places contains small cavities lined with iron oxide or with azurite crystals. More work has been done in this place than in the first open cut, yet less ore seems to have been taken out, to judge by the amount piled near by.

ELLIOTT CREEK.

General description.—Elliott Creek is a tributary of Kotsina River and joins it approximately 17 miles above the mouth of that stream, or 12½ miles almost directly east of the Copper River crossing. It is reached by a trail which leaves the Kotsina trail at Willow Creek and crosses Kotsina River by a bridge about half a mile above the upper end of the canyon. This trail passes over the southwestern spur of Hubbard Peak and reaches an elevation of approximately 2,700 feet before the descent to Elliott Creek begins. A second trail, used for the first time during the summer of 1907, leaves Elliott Creek (at Five Sheep Creek) about 6 miles above its mouth and, crossing the west end of the ridge to the south, leads to the Nizina trail not far east of the new Government bridge.

Elliott Creek is approximately 10 miles long and throughout most of that distance flows in a direction about N. 30° W., but makes a sharp southerly bend before joining Kotsina River. More than 2 miles of the lower portion is through a narrow rock-walled canyon, but the upper part, along which the claims extend for a distance of 4½ miles, lies in a narrow V-shaped valley. Between the upper cabin, situated about midway between the upper and lower ends of the claims, and the lower cabin, a distance of 2½ miles, the creek descends 759 feet, or approximately 360 feet per mile. Above the upper cabin this gradient increases as the head of the stream is approached. Elliott Creek is fed in a large measure by melting snow, and although the stream is not a large one, with the head available it is capable of furnishing considerable power.

The lowest and the only one commercially important of the rock formations exposed in the Elliott Creek valley is the Nikolai greenstone. All the copper prospects so far discovered here are associated with this rock. The massive bluish-gray Chitistone limestone is conformably overlain in some places by the black and gray Triassic shales and thin-bedded limestones cut by light-gray porphyritic dikes and sills, and in other places is succeeded unconformably by coarse conglomerate of the Kennicott formation.

In an ascent of Elliott Creek the greenstone and overlying limestone appear for the first time on Magpie Creek and continue eastward from that locality to the head of the valley. These two rock formations form a great anticline, whose axis is approximately parallel with the course of Elliott Creek. It pitches under the younger rocks at the east and west ends and dips into the ridges on either side of the creek. North of Elliott Creek and at its upper end the Chitistone limestone forms a very prominent topographic feature. With the exception of the Copper King and Mineral King, the claims described are on the north side of Elliott Creek, and are owned chiefly by the Hubbard-Elliott Copper Mines Development Company. The description of the claims is given in the order of their location from east to west.

Copper King and Mineral King claims.—The Copper King and Mineral King claims, often spoken of as "the Kings," are the most easterly claims on Elliott Creek. They are located along the limestone-greenstone contact, at an elevation of over 4,000 feet above the sea.

On the Copper King claim there is an open cut in the greenstone a little more than 100 feet below the base of the limestone cliff, 1,390 feet above the upper cabin. The copper minerals are found along a shear zone in the greenstone. Bornite is the principal copper ore and is seen along fractures and between them replacing the country rock. Calcite veins are not so numerous as might be expected near the limestone contact. The shear zone, which so far as can be determined at this exposure runs parallel with the base of the limestone N. 60° to 70° E. and dips to the south, is mineralized for a thickness of about 10 feet, though the copper-bearing solutions have penetrated the country rock for a greater distance, as is shown by a slight alteration of the greenstone. There is some pyrite in the ore, and besides malachite a blue coating of copper sulphate appears in protected places. This open cut is reached by climbing over a steep rock slide.

The two open cuts on the Mineral King are reached by another hard climb over a steep snow-covered talus slope. These cuts are about 800 feet northeast of the cut in the Copper King. The lower one was filled with snow at the time of visit, but the ore piled up at one side consisted of bornite replacing greenstone. The second cut, 50 feet higher and about 100 feet farther west, is almost at the same elevation as the Copper King cut. The ore was found on the steep face of the cliff and consists of chalcocite with a small amount of bornite replacing the greenstone along a fault or shear zone. Numerous close perpendicular joints running approximately N. 60° E. cut the greenstone, and there are a number of fault planes which strike N. 35° E. and dip 30° S. The trend of the disturbed zone is the same as that of the faults mentioned. The best ore has a thickness of about 6 feet and is traced for a distance of 25 to 30 feet along the strike, although the boundaries and extent of the ore body are somewhat indefinite. On the south, however, a fault plane makes a fairly well-defined wall. There is some rich ore at this exposure, but the development work is not yet sufficient to determine whether or not the ore body has any considerable extent.

Claim at the head of Queen Creek.—On the claim at the head of Queen Creek a small open cut has been made in the greenstone about 50 feet below the base of the limestone and shows small veins of calcite and a little quartz containing copper.

Van Dyke claim.—Two open cuts on the Van Dyke claim were visited, one 15 and the other 25 feet below the base of the limestone. The greenstone is stained with the oxidation products of iron and copper and contains also a small amount of pyrite, but the cut shows very little copper.

Copper Queen claim.—The open cut on the Copper Queen claim is about 50 feet west of Kings Creek. It has an elevation of 965 feet above the upper cabin. The cut is nearly filled by the caving of the bank above, so that the face of the greenstone was not exposed. A large mass of the rock, however, which lay at one end was filled with a great number of tiny intersecting veins of iron and copper sulphide, either pyrite and chalcopyrite or, more probably, copper-bearing pyrite. The greenstone fragments were covered with the green copper coating.

Marmot claim.—A large open cut has been made on the Marmot claim, at the base of the limestone between 200 and 300 feet west of Pouch Creek. The greenstone is much broken, and slickensided surfaces are numerous. The most prominent fault planes strike approximately N. 60° W. and are nearly perpendicular. Small calcite veins carrying a small amount of copper-bearing pyrite occur along some of the openings. A malachite coating was seen on the greenstone, but is not prominent along the main fault planes. Bornite was not observed.

Louise claim.—The Louise open cut is on the east side of Rainbow Creek and 50 feet above it, or 390 feet above the upper cabin. The country rock is greenstone and is cut by faults and joints. Slickensided surfaces are common. The best-developed fault planes strike about N. 20° W. and dip 45° to 50° W. Small calcite veins, having a thickness in general not greater than 2 inches and containing a little quartz, cross the country rock in all directions. Such veins are more numerous here than in most of the other workings examined. Bornite and chalcopyrite are the copper minerals present, and of the two bornite is the more abundant. They appear in the calcite veins and disseminated through the greenstone. The ore is best developed, however, in the calcite veins and the greenstone adjacent to them. It is difficult to give any definite statement of the thickness of the mineralized zone. The ore extends parallel with the creek for a distance of about 30 feet horizontally.

Above the cut on the steep hill slope green copper stains can be traced for a distance of 150 or perhaps 200 feet. Such an exposure as this may be the surface indication of an ore shoot, but the rich ore can not be traced for any considerable distance on the surface, usually not more than 25 feet and rarely as much as 50 feet.

Lizzie G. claim.—The open cut of the Lizzie G. claim is in the bed of Rainbow Creek only a short distance from the Louise. The greenstone at this place is sheared and plicated, but many of the resulting openings have been filled by infiltration of quartz and calcite. Quartz veins reach a thickness of 2 inches and carry considerable chalcopyrite. Calcite filling is, however, the more abundant and in places the rock consists of about equal amounts of sheared greenstone and calcite similar to the knotty masses of schist and quartz in many regions where metamorphism has been greater than in this area. These calcite-greenstone veins, if such they may be called, carry a considerable amount of bornite and chalcopyrite and make a fine-appearing copper ore, but the open cut does not show how great a quantity may be present.

Goodyear and Henry Prather claims.—Directly opposite the Louise open cut, about 40 feet west of Rainbow Creek and 340 feet higher than the upper cabin, an open cut has been made in the claim known as the Goodyear. The amygdaloidal greenstone is cut by faults and is much jointed. The most prominent of these faults strike north and south and dip about 40° W. Another set of less well-developed faults has a more easterly strike and a lower dip to the northwest. Between two of the north-south faults is a mass of rock lighter in color than the greenstone outside the faults. This lighter rock is sheared or sheeted parallel with the faults and is filled with a great number of thin calcite veins containing chalcopyrite or copper-bearing pyrite and bornite, something like the leaves of a book made of coarse paper. In the lower part of the cut this ore body is between 4 and 5 feet thick and forms a lenticular mass about 20 feet long bounded by two north-south faults and a northeast fault. The upper north-south fault is not continuous, but the lower foot-wall fault extends to the north for some distance. On the south this body of ore is much crushed and is filled with iron oxide. It can not be traced farther in that direction than the limit of the cut. Besides the thin veins of copper minerals in the sheeted rock, there are small veins of calcite and ore throughout the mass.

Along the strike a short distance to the north, and a few feet higher, the light-colored copper-bearing rock reappears, but the upper boundary of the mass is the fault which forms the lower boundary of the lower body. The ore body has a maximum thickness here of not less than 8 feet. An irregular branching calcite vein containing small horses of the light rock or main ore body reaches a thickness of 14 inches and contains chalcopyrite and bornite. This body of ore continues for a distance of 50 or 60 feet toward the north. These two bodies are portions of a single ore body included between two north-south faults and cut by later faulting.

Almost directly above the Goodyear, on the hill slope to the west and not more than 100 feet away, is the open cut of the Henry Prather. Here a north-south fault dips 60° W. and is intersected by two parallel faults striking N. 40° E. and dipping 30° to 35° W. These faults inclose a lenticular mass of rock 30 feet long and 5 feet wide, whose weathered surface is lighter in color than the inclosing greenstone and which is similar in all respects to the ore body of the Goodyear. This lighter-colored rock is impregnated in a similar manner with copper sulphides, and through it runs a vein of coarsely crystalline calcite carrying chalcopyrite and bornite, very rich in places. The calcite vein has an irregular thickness, ranging from 8 to 12 inches, and in two places is offset by small faults for a distance of 10 inches.

The main north-south fault may be traced to the north for about 75 feet and shows much green stain and some sulphides, but the large calcite vein and main ore body end, apparently having been faulted off. Almost 50 feet from the ore body the large fault is intersected by a northeast fault. This also shows copper stain and both contain small calcite veins with the sulphides.

Although no direct proof was obtained, the similarity in character and appearance of these two ore bodies of the Goodyear and Henry Prather suggests that they are faulted portions of one mass.

Elizabeth claim.—The Elizabeth claim lies north of the upper cabin and has received more attention in the way of development work than any other claim on the creek. This work consists of a tunnel and one or two open cuts. The tunnel is located in a narrow gulch a little more than 1,000 feet above the cabin. It has been driven into the greenstone in a northeasterly direction for a distance of 250 feet, and some ore has been uncovered, but it is not believed that the main ore body which outcrops on the hill above has been reached, and the work is to be continued. About 75 feet from the entrance the first copper appears in some lenticular veins of calcite and quartz, but there is only a small amount of this. In the face of the tunnel the greenstone is impregnated with bornite and chalcopyrite. Small veins of calcite also are present and carry the copper minerals. These small veins follow joint and slip planes in the greenstone and are rarely over half an inch thick. There is no well-defined master vein; the mineral waters appear to have followed a zone of fracture and faulting that runs, as closely as it is possible to determine at the tunnel face, in a nearly north-south direction. The greenstone has undergone considerable movement and slickensided surfaces are numerous. The slip planes and joints follow no definite general direction or, at least, this direction was not determined, if they do. At present the tunnel does not reveal the thickness of the ore-bearing zone nor even its direction with certainty.

In the gulch directly above the tunnel to the north and about 100 feet higher is an open cut exposing the copper-ore-bearing fault zone, which the tunnel is expected to cut. The greenstone is much shattered and shows a number of fault planes, the most prominent of which range in strike from N. 10° W. to N. 30° W. Movement along some of these planes has been very marked, and the rock is greatly crushed. Bornite and chalcopyrite are present in small calcite veins and also impregnating the greenstone in and adjacent to the fault zone. The green stain due to oxidation is prominent here, as it is in all places where the copper minerals occur, and makes it possible to trace the copper-bearing zone from the open cut in a direction N. 12° W. for several hundred feet up the hill, where several other small open cuts have been made.

Marie Antoinette claim.—Copper ores are exposed in the Marie Antoinette claim in two open cuts on the top of a narrow ridge adjoining the Elizabeth claim on the northwest. These cuts are within less than 100 feet of each other and show shattered greenstone stained with the oxidation products of iron and copper. There are a number of faults which strike in different directions, and in the open cut on the west brow of the ridge a crushed vein of variable thickness, consisting of calcite and a small amount of quartz, is exposed. The greenstone also contains veinlets of calcite which follow joint or slip planes and carry copper and iron sulphides. The larger vein strikes approximately N. 30° W., a direction which would take it somewhat to the south of the other open cut. Near it a small perpendicular dike of fine-grained diorite from 2 to 2½ feet thick cuts the greenstone.

Albert Johnson claim.—The Albert Johnson claim and the Guthrie claim described below adjoin each other end to end and lie parallel to the greenstone-limestone contact, but slightly below it. Deception Creek crosses their common end line at an angle of about 45°. Some open-cut work has been done, and a tunnel has been driven on the Albert Johnson about 100 feet east of Deception Creek. The tunnel is 30 feet under cover and is not over 150 feet below the base of the Chitistone limestone exposed to the north in the creek.

Small, nearly horizontal faults cut the greenstone, and the rock is otherwise broken by joints, giving it a blocky character. Calcite veins are present, but not abundant. Copper ore is exposed in the tunnel and in the open cuts. When a piece of the copper-bearing greenstone is broken, bornite and chalcopyrite are found to be the copper minerals, the bornite predominating. The fault zone in which the copper sulphides occur can be traced by the green stain in a nearly horizontal plane almost around to the Guthrie tunnel, so that these two appear to form parts of one ore deposit.

Guthrie claim.—The tunnel of the Guthrie claim is on the hill slope west of Deception Creek, directly opposite the Albert Johnson tunnel and about 200 feet from it, but 10 or 15 feet higher. Above the tunnel for a distance of 40 or 50 feet the surface of the country rock has been cleaned off, exposing small veins of calcite in shattered greenstone; these veins carry the sulphides bornite and chalcopyrite. The freshly broken greenstone adjacent to these small veins is also seen to be impregnated with the sulphides. There is no well-defined vein, but the jointing or faulting has permitted the mineral-bearing waters to circulate through a shattered zone in the greenstone. The tunnel is not more than 100 feet below the base of the heavy limestone as it is exposed in the creek to the north, which would account for the considerable amount of calcite present in the greenstone.

Leland and Lawton claims.—The Leland and Lawton claims are located in the saddle between the heads of Five Sheep and Deception creeks, which here has an elevation of more than 2,500 feet above the lower cabin. They lie north of the main body of the Chitistone limestone, whose scarp forms the prominent cliff on the southern brow of the spur to the south. This unusual location apparently above the limestone is due to faulting, which brings the greenstone up against the Kennicott formation or, rather, against the large porphyritic dike which here separates these two formations. On the Lawton claim a fault which strikes N. 30° W. and dips 50° to 60° S. is seen between the greenstone on the south and the porphyry dike on the north. The dike here shows a thickness of 30 to 35 feet. Several open cuts have been made in the greenstone and show small amounts of pyrite and chalcopyrite impregnating the rock adjacent to joint or fault planes. Green copper stain and also copper sulphate were seen in a number of other places. The copper minerals where observed were all within a few feet of the porphyry dike, but any other relation between the two was not evident.

Cliff claim.—The Cliff claim is on the west side of Deception Creek. Two open cuts have been made at an elevation of 600 feet above the mouth of this stream. The greenstone is cut by numerous fault planes and slickensided surfaces are abundant, but perhaps the most prominent of the planes of movement strike nearly east and west and dip about 45° N. The green copper carbonate and the oxide of iron stain the greenstone. Small amounts of the copper sulphides also are exposed along joint planes, but no considerable exposure of ore has been made.

Chance claim.—The Chance is the most westerly of the patented claims and includes the prominent point of the limestone cliff which is seen on entering the valley. A small open cut only a few feet below the base of the limestone shows the green copper stain and a little bornite in the greenstone.

KUSKULANA RIVER BASIN.

GENERAL DESCRIPTION.

Kuskulana River receives its greatest supply of water from Kuskulana Glacier, an ice stream made up by the union of four principal branches coming down from the southwest side of Mount Blackburn. The river is a little over 21 miles long and in the upper half passes through a broad gravel-floored glacial valley between high, rugged mountains. After leaving the mountains it flows for more than 10 miles, most of the way in a narrow rock-walled canyon, across the broad valley of Chitina River and joins that stream 10 miles above Copper River. Strelna Creek is the largest tributary of Kuskulana River. It rises in the mountains about the head of Elliott Creek and joins the Kuskulana 3 miles from Chitina River, thus having a length of 12 miles.

Most of the copper prospects are in the vicinity of Kuskulana Glacier, where the Nikolai greenstone and Chitistone limestone are well exposed. There are, besides these two formations, some rocks of doubtful identity in the vicinity of Nugget Creek, a western tributary joining Kuskulana River just below the glacier. These rocks are probably the same as some at the head of Kotsina River which have been included with the Nikolai greenstone, but may be older. Triassic shales and limestones are well developed east of the Kuskulana and are also represented in a small area west of it.

The best-known copper properties of this area are on Nugget Creek, but there are other prospects on one or two neighboring streams tributary to the main river on the west side and in the vicinity of the glacier on the east side as well as on Slatka and Trail creeks. There are also a few prospects on the head of Strelna Creek.

NUGGET CREEK.

General outline.—Nugget Creek drains the southeast side of the mountain mass whose northwest side is drained by Peacock, Roaring, and Rock creeks of the Kotsina basin. Several of its branches are fed by small glaciers. The stream is about 6 miles long and joins Kuskulana River less than a mile below the glacier.

The country rock includes amygdaloidal greenstones and other greenish rocks which differ somewhat in appearance from typical exposures of the Nikolai greenstone and might be separated from it on closer study. A small area of Chitistone limestone outcrops on the mountain slope east of the upper part of Nugget Creek, and near it along the creek bed is a small exposure of gabbro.

Most of the copper prospects, of which there are a considerable number, are situated in the lower or southern part of Nugget Creek valley. Collectively they constitute the Alaska Consolidated Copper Company's properties, only a part of which were examined by the writers. The claims on which most work has been done are located on the small rounded hill between the lower end of Nugget Creek and Kuskulana Glacier. It was not possible in the short time available to visit any other properties than those on this hill, so that no description of claims in the Nugget Creek valley north of the hill or west of the stream can be given. A good trail leads from the creek's mouth to the camp, where several very comfortable cabins have been built.

Valdez claim.—On the south slope of the rounded hill referred to above is a claim called the Valdez. It is crossed by a fault or set of parallel perpendicular faults running N. 65° E., along which the ore is deposited. The continuation of the fault or faults for a distance of several hundred feet is shown by a line of test pits, but how much farther they extend was not learned. A tunnel run in toward the north and 30 feet under cover gives a cross section of the deposit. At the mouth of the tunnel is greenstone separated by a fault from a large calcite vein on the north. The calcite vein has a width of 24 feet, as measured along the tunnel wall. This wall, however, is not exactly perpendicular to the course of the faults. After passing through the calcite vein the tunnel penetrates a close-grained dark-gray rock, possibly one phase of the greenstone series, for a distance of 5 feet. This rock and the vein are separated by a fault, along which is a seam of blue and yellow clay, ranging from 2 to 3 inches in thickness and containing small crystals of chalcopyrite. All of the calcite vein as exposed in the tunnel is ore. Bornite is the principal copper mineral and is accompanied by chalcopyrite in minor amount. Movement has taken place along both faults since the ore was deposited, and the country rock as well as the vein matter is jointed and crushed. The greenstone is sheeted parallel to the fault, but the harder close-grained rock in the face of the tunnel was more resistant and broke in angular blocks. The calcite vein is also much broken and in places granulated.

A prospect hole or crosscut a short distance northeast of the tunnel did not expose the vein, but 300 feet still farther northeast an open cut shows greenstone faulted against a light-colored rock consisting chiefly of calcite and quartz, much shattered and impregnated with bornite and chalcopyrite.

Thirty feet to the southwest along the vein from the tunnel mouth is a shaft which in August, 1907, was partly filled with water, but was said to be 30 feet deep. The shaft is sunk in the vein matter, but here the vein has a thickness of only 8 or 9 feet. On the north side is greenstone, much sheared and containing thin calcite veins accompanied by bornite. It is not evident from the exposures why the position of the greenstone with reference to the calcite vein is here reversed. The ore is similar to that in the tunnel. No traces of the vein or fault were seen on the grassy hill slope southwest of the shaft nor were they expected since no test pits had been dug and the country rock was not exposed.

One Girl claim.—The One Girl claim is on the west slope of the hill between Nugget Creek and the lower end of Kuskulana Glacier. A tunnel called the " mud tunnel " has been driven on the south side of a small gulch and extends into the hill for 100 feet in a direction S. 75° W. Of this tunnel 91 feet is in frozen slide rock and is reported to have caved in sometime during the early fall. The remaining 9 feet of the tunnel is in amygdaloidal greenstone, the cavity fillings being calcite. No ore was observed in the face, but the tunnel had not been extended far enough to encounter the mineralized body of rock seen on the hill, nearly 300 feet higher than the tunnel, toward the southeast. This " lead " is amygdaloidal greenstone country rock impregnated with fine particles or grains of chalcocite in association with small calcite veins and epidote. Several open cuts extending along a line from southwest to northeast show the same copper-bearing greenstone, but no work has been done to indicate the width of the zone or any of its other dimensions.

This ore, if the copper content is sufficient to warrant the use of the term under the conditions prevailing in Alaska, is similar in many respects to that of the Copper Queen claim north of the Nugget Creek camp.

Nugget Creek received its name from the large mass of native copper found in the creek bed a short distance above the camp. This nugget is estimated to weigh between 2 and 3 tons and is too heavy to be removed economically by means of transportation now available. It is 7 feet in its greatest dimension, 3 feet 2 inches wide in the middle, and has a maximum thickness of 12 inches, but the average thickness is probably less than 6 inches. Many smaller nuggets ranging in size from shot to pieces of several ounces or pounds are found in the gravels of the creek, but their bed-rock source has never been discovered.

STRELNA CREEK.

The copper prospects of Strelna Creek are of interest chiefly as showing the close relation between copper deposition and the limestone-greenstone contact. The Chitistone limestone forms numerous cliffs in the upper part of the creek, particularly on the branch leading to the Elliott Creek pass.

About a mile southeast of the Elliott Creek pass a small area of Chitistone limestone caps the greenstone of the ridge south of Strelna Creek. The north contact of the two formations is here a fault contact. From 6 to 8 feet of the decomposed greenstone along the fault is heavily mineralized with pyrite, weathering to brown iron oxide. Along with the pyrite is a little copper, as is shown by the green stain of malachite. In the heavy overlying limestone, but not over 10 to 20 feet above the contact, thin veins of copper-bearing pyrite were seen in the limestone. Stringers and small bunches of ore are not uncommon in the underlying greenstone at various places on the creek.

LAKINA RIVER.

Lakina River rises in an area of glacial drainage of minor importance lying between the much more extensive basins of the Kuskulana Glacier on the west and the Kennicott Glacier on the east. The Lakina is not as large nor as turbulent a glacier stream as the Kuskulana or the Kennicott.

The trail regularly traveled through this region reaches Lakina River about 6 or 7 miles below the lower ends of the two glaciers from which the river emerges. This portion of the valley of the Lakina differs somewhat from those of Kuskulana and Kennicott rivers where they flow from their glacial sources, in that it has a more basin-like expansion in its lower half. This basin-like expanse, which is about 2 miles wide along the trail and gradually narrows into a mountain gorge valley one-half mile wide toward the head of the river, as the glaciers are approached, is floored with deposits of gravel, sand, and mud.

In an ascent of Lakina River from the main trail, the first bed rock to present itself along the margins of the flat gravel floor of the valley is the Nikolai greenstone. This rock appears on both sides of the valley where it begins to become more restricted, about 3 miles below the glaciers, and rises in steep mountain slopes on both sides. Above the greenstone the Chitistone limestone presents its characteristic cliff-like faces, and above the Chitistone limestone a series of shales and thin-bedded limestones form on the east side of the valley bare slopes that are also present, though not so evident, on the heights west of the river.

The camps of two prospecting parties are located within a few hundred yards of each other on the west side of the Lakina, about a mile below the glaciers from which the river flows. The copper prospects occur at comparatively low elevations above the river, in the greenstones that form the steep western side of the valley at this place.

The prospect farthest up the river is about 250 feet up the mountain side from the upper cabin. A short open cut, about 6 feet deep, has been made on a shear or minor fault plane that strikes N. 30° W. and dips 70° SW., into the country rock of amygdaloidal greenstone, which, at this place, is weathered to a reddish-brown color. The walls of this plane are separated at this opening for about 2 feet, and the space thus formed contains a filling of crushed and slickensided slabs and fragmental pieces of the country rock, the whole being cemented together by the deposition of quartz in the interstices. The quartz in one place is somewhat continuous along one of the walls for a few feet and has a thickness of 1 to 2 inches. Most of the filling, however, is crushed country rock. A small amount of native copper in the form of specks and scales occurs within this filling. The amygdaloidal greenstone country rock just north of this filled space is checked with thin veinlets of quartz and contains some scattered chalcopyrite in specks and films. The small size of the opening makes it impossible to give any idea of the extent or amount of mineralization at this place.

The second prospect of this vicinity is similarly located on the lower slopes of the mountain side only a few hundred yards south of the one just described. At this locality the natural exposure of the rocks is good enough to exhibit the so-called pseudobedding that the Nikolai greenstone shows in many localities. Here this bedlike structure of the greenstones strikes N. 70° E. and dips 45° SE. Apparently there has been some shearing or movement along a major plane of pseudobedding or faulting, as well as movements along joint or other pseudobedding planes parallel to the principal one. This is shown by clean block or slab spalling for a distance, on the strike and dip above recorded, of 500 to 600 feet. This well-exposed face extends up the mountain side to the west and above the camp in a diagonal direction. The surface of the exposure is a natural dip slope along the major pseudobedding plane, offset somewhat by parallel bedding or joint planes. Slickensided surfaces may be observed along the joints or planes, and a tendency toward plication, indicative of shearing movements, is present. A small stream flows down over the surface of this rock incline. Along the major pseudobedding plane at this locality there is a somewhat continuous sheetlike filling of rock that does not look very different from some phases of the country rock at this locality and elsewhere. This sheetlike filling ranges from 1 to 6 or 8 inches in thickness and, as the surface of the rock incline is now exposed, this material lies in patches as a veneer over the surface of the country rock. It does not appear to be so markedly siliceous as the filling in the prospect several hundred yards to the north. It is this filling that contains the native copper in specks, flakes, slugs, and nugget-like lumps. No pieces of native copper of large size were observed, the largest pieces seen being about 2 inches by half an inch in area, and the size of these, as they are exposed on the surface, is due to the flattening and spreading to which they have been subjected by the impact of material carried down over this steeply inclined rock surface by the stream. The surface exposure of this sheet of native copper-bearing material, which lies bare over an area of about 400 by 20 to 30 feet, has been well picked over for specimens, and most of the larger pieces of copper originally present have been removed. For this reason it is impossible to give an estimate of the quantity of native copper that a given volume of the sheetlike filling along this sheared pseudobedding plane may have originally contained. No work has been done in opening up the locality to show how extensive or persistent the deposit may be in any direction, and there appears to be no evidence to justify an assumption that there is a mass of native copper-bearing rock 20 to 40 feet wide extending into the mountain in a direction perpendicular to the strike of the pseudobedded structure.

High up on the mountain side, 2,400 feet above and three-fourths of a mile west of the camps on the river, some surface stripping has been done that exposes a fault in shattered amygdaloidal greenstones. This fault strikes N. 15° E. and dips 75° W. The walls are 18 inches apart and the space is occupied by what appears to be a gouge of crushed country rock, the 6 inches of material adjacent to the hanging wall being essentially earthy and the remaining 12 inches on the foot wall being cemented by a quartz filling. Apparently just enough copper-bearing mineral matter is associated with this cemented gouge to stain the surface of the 18 inches exposed with green carbonate films. Apparently no other copper minerals were present, although there may be such finely disseminated through the cementing material. A very little bornite in specks and stringers not over one-eighth inch thick was observed in a piece of loose material at this place.

KENNICOTT RIVER BASIN.

ROUTE.

The summer trail that leads through the mountains east of Lakina River to the Kennicott Glacier follows the banks of the Lakina to Fohlin Creek, a tributary flowing from the north. The trail then ascends Fohlin Creek about 2 miles to its first large tributary from the east, locally known as Bear Creek, and continues up the valley of Bear Creek to Kennicott or Fourth of July Pass. From this mountain gap the trail descends Fourth of July Creek to the western margin of the Kennicott Glacier, along which it continues to Kennicott River.

HIDDEN CREEK.

Hidden Creek is a tributary to Kennicott Glacier on its west side, about 4 miles northeast of the mouth of Fourth of July Creek. It presents a feature of lateral valley drainage that is unique in a way, yet also characteristic of many glacial valleys that are tributary to larger glacial valleys where the main ice stream still flows past and completely dams the mouth of the smaller valley. Considered by itself, the valley of Hidden Creek presents all the features of larger glacial valleys. The head of the valley comprises ample cirque basins for the accumulation of snow and its transformation into the ice of the comparatively small glaciers that now exist at its head. These glaciers flow from their basins and terminate well down toward the valley level, but do not extend into its flatter main portion. From them issue small streams that within a short distance join to form a good-sized creek that flows down over the gravel-floored part of the valley. At its lower end the valley of Hidden Creek is completely dammed by the Kennicott Glacier, which ponds back the waters of the stream so as to form a lake which occupies the entire lower valley. This body of water is known as Icy Lake. It is one-half mile across and extends 1½ miles up the valley to a point where the gradually ascending gravel floor rises above its surface. This gravel floor continues as bare flats to the foot of the slopes of the cirque basins, from which the small steep glaciers occupying the head of the valley descend. The stream flowing over it from the glaciers at its head to the lake at its foot is about 2 miles long and has been well named Hidden Creek, as its existence is not to be suspected and it can not be seen until the valley is actually entered. About half a mile above Icy Lake, on the south side of the valley, a small stream that heads near Fourth of July Pass flows out of a steep mountain gorge. This stream is locally known as Glacier Creek.

The steep walls of both the north and south sides of the valley of Hidden Creek expose on the lower halves of their slopes the Nikolai greenstone, above which rise practically inacessible cliffs of the massive Chitistone limestone. A number of lode claims have been located along the contact of the greenstone and overlying limestone, where in places a little evidence of copper mineralization is to be seen. Most of these locations were made in 1906, and during the summer of 1907 assessment work was performed on them with a view to prospecting the ground.

The Great Northern Development Company had in this neighborhood for part of the season a crew of men who expended most of their labor in making a trail to the valley by following the steep mountain that bounds the western side of the Kennicott Glacier for a couple of miles south of Hidden Creek. This trail was not completed.

The only actual work on claims located in the Hidden Creek valley was done by the Valdez Exploration Company. This company packed its supplies with horses up a trail over the western lateral moraine of Kennicott Glacier to the Hidden Creek valley, thence, by a hazardous route across the ice that dams that valley, to the north side, and thence up the northern shore of Icy Lake to its head. The camp was located 500 feet above the bed of Hidden Creek, on a small area of bench ground, about 4,100 feet above sea level, that still remains in the fork formed by the junction of Hidden and Glacier creeks. During the summer season of 1907 five or six men were employed by the company in prospecting a group of twenty-five lode claims, more or less, some of which are located on the greenstone-limestone contact that extends along the south side of the Hidden Creek valley above Glacier Creek. About half a dozen claims extend from this group along the contact to the west and across the course of Glacier Creek into an area of greenstones. Another chain of claims has been located up the valley of Glacier Creek and across the divide at its head into the headwater drainage area of Fourth of July Creek.

Most of the work on Hidden Creek is on its south side about a mile above the camp, and consists of open cuts in the greenstones about 300 to 400 feet below their contact with the overlying limestones. All the work done during 1907 was necessarily in the form of open cuts because of the difficulty of getting supplies into the place, especially timber for tunnel work, necessitated by the condition of the rock. No timber of any kind grows near Hidden Creek. Five open cuts were seen on claim No. 3 at this locality, at an elevation of 4,800 to 4,900 feet above sea level, in much-sheared greenstones, the shattered blocks and fragments of which are tightly keyed into one another. The displacements that the greenstones have undergone at this place have been severe enough to obscure their pseudobedded structure to a large extent. The mineralization through and between these keyed shatter blocks consists of irregular and disconnected stringers of bornite, with lumps of the same mineral, some of which may weigh as much as 20 to 30 pounds. There is no continuity to the mineral deposits. They appear to be scattered erratically through the greenstones in an irregular zone for a width of 25 to 75 feet, and by far the greatest amount of this material is only shattered country rock.

GLACIER AND FOURTH OF JULY CREEKS.

Nebraska claim.—About three-fourths of a mile up Glacier Creek, at an elevation of approximately 4,800 feet above sea level, an open pit 8 feet square and 8 feet deep has been sunk, on what is called the Nebraska claim, in a shattered mass of the greenstone that forms a low knoll in the valley. This knoll appears to be a slide mass from the mountain side on the east. Green copper-carbonate stains, specks of bornite, and one speck of chalcopyrite were observed in some of the pieces of rock that came from this pit, but nothing more was revealed. There is said to be a surface showing of chalcocite, on which no work has been done, in the greenstones about 400 feet below the limestones on the southeast side of Glacier Creek opposite the camp.

Bekka and Eli claims.—Above the Nebraska claim the Chitistone limestone dips southward under thin-bedded limestones and shales. But the stratigraphic continuity of the rocks that occupy the headwater areas of Glacier and Fourth of July creeks is disturbed by a line of major faulting that passes in an east-west direction through the head of Fourth of July Creek. This fault throws the heavy-bedded Chitistone limestone to the surface again on the divide between Glacier and Fourth of July creeks, where it is exposed for a thickness of about 600 feet. There is probably a minor fault that passes across Glacier Creek north of and parallel to the major displacement on Fourth of July Creek. Over this faulted area the Bekka and Eli claims extend, crossing the divide to the head of Fourth of July Creek, where the major fault brings the thin-bedded limestones and shales against the greenstones. In the greenstones at the head of the creek, about 200 feet below the massive Chitistone limestone, is a bed of crystalline rock about 30 feet thick that has the attitude of a sill. Above the sill-like rock at this place is typical amygdaloidal greenstone that does not appear to be altered from its usual texture in any way. Along the contact between this crystalline rock and the overlying amygdaloidal greenstone are a few thin seams of chalcopyrite, and there are also specks of this mineral within the amygdaloid a few inches from the contact. Bornite occurs associated with this chalcopyrite in very small quantities, and the presence of a small amount of chalcocite is suspected by its presence in a piece of rock float picked up below.

Realgar.—About one-third of a mile farther down Fourth of July Creek there is an occurrence of realgar (sulphide of arsenic). The mineral fills small spaces in a crushed zone in thin-bedded limestones. Some of the spaces are filled for a width of 1 to 2 inches with well-formed crystals, but other seams contain the realgar in a more impure earthy form. The rest of the shatter spaces of the limestone are largely filled by thin seams of calcite. No considerable amount of realgar appears to be present at this place.

Coal.—On the divide between Fourth of July and Bear Creeks to the north of the pass crossed by the trail, at elevations of 5,800 to 6,000 feet, is a small patch of coal-bearing shales and flaggy arkosic sandstones covering an oval-shaped area of about 20 acres. The thickness of these beds is probably not over 50 feet. They are partly covered by more recent andesite lava that occupies a smaller area and stands at its highest point as a pinnacle about 50 feet thick. These rocks, which may be provisionally assigned to the Tertiary, appear not to have been involved in the major fault that is well exposed on the head of Fourth of July Creek, which brings the Nikolai greenstone and Chitistone limestone, to the north, against the thin-bedded limestones and shales, to the south. The Tertiary coal-bearing beds seem to lie in a nearly horizontal position on top of the inclined beds of the older series. The coal was not seen in place, its presence being indicated only by small weathered fragments mixed with the disintegrated shales. It is probably not of workable thickness, and even though it were, the small amount and its inaccessibility would prevent it from becoming of commercial importance.

BONANZA CREEK.

The Bonanza, the most valuable known copper deposit of the Chitina Valley, is situated at the head of Bonanza Creek about 1½ miles east of Kennicott Glacier and 7 miles north of the glacier's southern extremity. It is the property of the Kennicott Mines Company and is the only property visited during the season that gives promise of shipping ore in a commercial way in the near future. Two other groups of claims, known as the Jumbo and Independence groups, are situated in the near vicinity and are owned by the same company.

Bonanza Creek is about 3 miles long and heads on the west side of the high mountain ridge running north and south between Kennicott Glacier and McCarthy Creek. Its general course is to the southwest. The company's main camp and office, however, are located at the mouth of National Creek, almost 4 miles by trail from the mine. A new trail, sufficiently wide for a wagon road, is nearly completed and leads from the lower camp to the upper one, and a second trail of easy grade and good width leads down the east side of the glacier to the Kennicott River crossing.

South of National Creek the high north-south ridge between the glacier and McCarthy Creek is made up of Triassic shales and limestones intruded by large masses of a light-gray quartz porphyry. These Triassic rocks and the intrusive are separated by a great fault from the greenstone and overlying Chitistone limestone on the north. The strike of the limestone is northwest and southeast, and its dip averages between 25° and 35° NE. It therefore cuts diagonally across the main ridge and appears at the glacier's eastern edge nearly 9 miles north of the head of Kennicott River. The limestone here has a thickness of more than 1,000 feet. Still farther northeast the Triassic shales conformably overlying the heavy limestone reappear, but they do not occur within the area of the copper-bearing rocks. Bonanza Creek and the other creeks where copper claims have been located lie wholly within the greenstone-limestone area.

The Bonanza mine is situated on the west side of Bonanza Creek on a spur running down to the southwest from the main ridge. This spur divides Bonanza Creek from a small southwestward flowing tributary heading just west of the mine and is crossed by the greenstone-limestone boundary about one-half mile southwest of the main ridge. On the axis of the ridge this boundary has an elevation of approximately 6,000 feet above sea level, or 3,800 feet above the mouth of National Creek, where the ore bins are to be built. To the southwest the spur is greenstone; to the northeast it is limestone, rising to an elevation more than 1,000 feet greater than that of the contact.

The base of the limestone consists of not less than 40 feet of coarse gray limestone rock filled with cylindrical bodies which look like worm borings or seaweed. Over this is a few feet of impure shaly limestone, which in turn is overlain by dark and light-gray massive beds which carry the ore bodies. The ore is chalcocite, with which is associated, as an alteration product, in some places at least, considerable quantities of azurite. The limestone is broken by numerous faults and fracture planes, the most prominent of which are nearly perpendicular and range in direction from N. 40° E. to N. 70° E. Another set of faults runs in a northwesterly direction, and in several places striations on the slickensided surfaces or the clay seams show that the movement was horizontal. Horizontal fault surfaces are also present. None of the faults observed give evidence of any very great displacements, but, together with the numerous joints, they gave opportunity for ore-bearing solutions to enter the limestone. The principal fault planes—those running from northeast to southwest—form what may be described as a sheeted zone in the limestone. In this sheeted zone are the principal ore bodies. In places numerous closely spaced parallel fractures which contain thin veins of copper ore may be seen, especially near the north end of the deposit. This sheeted zone is not very conspicuous in the limestone beds and greenstone southwest of the main ore body, nor does it extend in a well-developed form for any considerable distance northeast of it.

The copper ores are chalcocite and azurite. The chalcocite is in veins of solid ore up to 5 or 6 feet in thickness and in large, irregularly shaped masses. On the surface two principal veins are seen. They stand almost perpendicularly, 12 to 15 feet apart, and strike N. 41° E., forming the comb of the sharp ridge, but crossing it at a slight angle, as the ridge at this place has a more nearly north-south direction than the veins. In places the precipitous west face of the ridge is a mass of solid chalcocite for a distance of 50 or 60 feet vertically below the top. Azurite appears on the surface of the glance and also as a lining of small vugs in the glance, but it is present chiefly as thin veins that form a network in the limestone and probably are due to the alteration of original chalcocite veins, for much of the azurite has an inner core of chalcocite. Azurite is more conspicuous than chalcocite in the northern 150 feet of the ore body, but chalcocite forms the great mass of the remainder. The ore bodies formed along the northeast-southwest faults of the northern part of the deposit are not the direct continuation of the large chalcocite veins at the south, but lie in nearly parallel veins which cut the ridge at a greater angle, their strike being about N. 60° to 70° E. The very rich ore can be traced on the surface for a distance of about 250 feet. It ends abruptly on the south in a nearly vertical limestone wall, but on the north gives place to the lower-grade ores, consisting of small veins of azurite and chalcocite, with scattered masses of chalcocite, some of them weighing several tons. This lower-grade ore shows on the surface for a distance of at least 150 feet northeast from the high-grade ores, and small scattered azurite veins extend still farther in that direction. The ore, as it shows on the surface, therefore, extends northeast and southwest along the strike for a distance of 400 feet. The thickness, however, is more indefinite, but the very rich ore, with its included limestone, as seen at the surface, has a width of approximately 25 feet, although the thickness of ore sufficiently rich to be mined may be greater.

Two crosscuts have been driven in the ore body in a direction N. 33° W. They are therefore not exactly perpendicular to the ore body. The longer of these crosscuts starts on the east side of the ridge, 75 feet below its top. It is 180 feet in length and extends through to the west side of the ridge. The richest ore, consisting of large masses of chalcocite with some included limestone, is encountered at a distance of 90 feet from the tunnel's mouth and continues for a distance of 21½ feet, as measured in the roof. There are smaller bodies of chalcocite, however, for a distance of 10 or 15 feet on either side of the main ore body. About 115 feet from the entrance to the tunnel a winze 30 feet deep was sunk in the ore, and from the bottom a drift, which cuts some rich ore and also some of the lower-grade azurite-chalcocite limestone body, zigzags to the northward.

About 120 feet southwest of this tunnel is a parallel tunnel driven from the west side of the ridge and 50 feet lower than the little saddle above it. This tunnel starts in a face of solid chalcocite and extends S. 33° E. for 50 feet. The ore, which is chalcocite with a small amount of azurite, extends for 34 feet along the tunnel, but is interrupted by horses of limestone. The remainder of the tunnel shows limestone cut by small azurite veins and in places containing a small amount of chalcocite.

From the description that has been given, it will be seen that there is little on the surface or in the tunnels by which to determine whether the ore body has a greater extension from southwest to northeast than about 400 feet or, at most, 450 feet, or whether it extends down into the basal beds of the Chitistone limestone. It is evident, however, that the Bonanza is an exceedingly rich and unusual body of copper ore.

JUMBO CREEK.

From the Bonanza mine the Chitistone limestone continues northwestward in a succession of lofty cliffs as far as Kennicott Glacier. The base of these cliffs is at the greenstone contact and in many places contains veinlets and stringers of azurite or chalcocite. In at least two places the quantity of these two minerals, especially of the chalcocite, is such as to make the deposits of commercial importance.

The ore body of the Jumbo claim is 4,600 feet northwest of the Bonanza, at the head of Jumbo Creek, and is located in limestone just above the greenstone-limestone contact on a small southwestward-projecting spur or angle of the limestone cliff. South of it and nearly 200 feet below is the glacier in which Jumbo Creek heads and which must be crossed to reach the ore body. The Jumbo and Bonanza ore bodies are at practically the same elevation above sea level, approximately 6,000 feet.

The limestone at the Jumbo is made up near the base of slightly cherty beds, ranging in thickness from 8 to 12 inches. The strike is

N. 65° W.; the dip 35° N. A tunnel 12 feet long was started on the south face of the ridge, 10 feet above the greenstone. The limestone is jointed or cut by minor faults parallel to the bedding and is crossed by veins of calcite from 1 to 2 inches thick. Thin veins of chalcocite and azurite accompany them and fill some of the fractures. Seven feet above the tunnel mouth is the east end of a large chalcocite mass which is well exposed on the axis of the ridge. As indicated on the surface, this body of ore is a mass of solid chalcocite, 30 feet long, 6 feet by 4 feet 6 inches at the west end, and tapering to a diameter of 1 foot at the east end. It is a rudely conical body, but has irregularly shaped protuberances, as may be seen at the west end, where the steep west face or slope of the spur gives a cross section of the ore body.

A little way east of the Jumbo tunnel is a second tunnel in limestone a short distance above the greenstone. The tunnel runs nearly north or slightly to the northeast, in limestone that strikes N. 65° W. and dips 25° N. In the tunnel, which is 12 feet long, the limestone is crushed and jointed. Small veins of calcite and azurite up to 2½ inches in thickness fill joint cracks, especially a set of perpendicular minor faults or slip planes running N. 70° W. No chalcocite is exposed in the tunnel, but it is believed that the azurite indicates its former presence. Fifty feet below the tunnel a lenticular vein of chalcocite, 3 inches thick at its widest part and 3 feet long, was found in the limestone.

OTHER CLAIMS.

Northwest of the Jumbo claim and nearer Kennicott Glacier is another chalcocite body of similar character that is said to be larger than the Jumbo. This property was not visited by the Survey party, nor was the Independence group of claims, which lies just below the top of the ridge between Bonanza and McCarthy creeks, on the McCarthy Creek side. The vein of the Independence is in greenstone and is described by Mendenhall[a] as being a fairly persistent fissure vein from 6 to 8 inches wide and trending obliquely to the limestone-greenstone contact. The ore is essentially bornite, but is associated with a small amount of chalcopyrite. The gangue is calcite and crystalline quartz, but a considerable part of the ore is without gangue and is relatively pure. The walls of the vein are fairly well defined, but the ore is observed to gradually fade away into the country rock on the eastern side of the gulch in which the vein is exposed.

The Nikolai mine on Nikolai Creek, a tributary of McCarthy Creek emptying into Kennicott River a short distance below the glacier, was not visited by the Survey party, as no work has been done there since the claim was patented, and the shaft was reported to be filled with snow and ice.

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[a] Mendenhall, W. C., Geology of the central Copper River region, Alaska: Prof. Paper U. S. Geol. Survey No. 41, 1906, p. 104.

CHITISTONE RIVER BASIN.

MAIN STREAM.

Chitistone River is a southwestward-flowing tributary of the Nizina and joins that stream approximately 30 miles above its mouth. It heads in the glaciers which cover the divide between Copper and White rivers, and its valley is one of the routes by which prospectors reach Skolai Pass and the White River Glacier. Between the lower end of the Chitistone Glacier and Nizina River the stream has a length of 18 miles, but the copper properties on which most work has been done are situated within the lower 10 miles of the valley. Within this lower 10 miles of its valley Chitistone River flows over a broad gravel-covered flat, ranging in width from one-half mile to 1 mile. The largest tributaries are Glacier and Toby creeks, both flowing in a northwesterly direction and joining the main stream within 2 miles of each other. The mouth of Glacier Creek, the more westerly of the two tributaries, is 7 miles from Nizina River. The larger tributaries, including two or three besides the two named, have broad gravel-covered valley floors similar to that of the Chitistone itself, but much narrower and with higher gradients. The smaller tributaries tumble down steep rock-walled gulches.

For more than half its length the valley of Chitistone River is cut in Nikolai greenstone and the overlying heavy Chitistone limestone. In this vicinity the limestone reaches the maximum thickness observed, at least 2,000 feet. South of the river it dips gently northward, forming a conspicuous cap on the greenstone that may be seen for many miles to the southwest and everywhere lies at least 1,000 feet above the valley floor. On the north side of the river, between the Nizina and Glacier Creek, the whole mountain mass, with the exception of 200 or 300 feet at the base, is Chitistone limestone extending to an elevation of more than 4,000 feet above the valley. On the west side of Nizina River the limestone dips to the north at about 30°, so that the great thickness on the east side represents the central low-lying portion of a large syncline. Farther up the valley Triassic and other younger rocks with granular intrusions and included coal beds appear.

Copper is found on Chitistone River in both the greenstone and the limestone, but in 1907 development had not revealed any considerable ore bodies. On the Chitistone itself most of the work had been done by the Houghton Alaska Exploration Company and by the Alaska United Copper Exploration Company, the first-named company directing its efforts to prospecting claims north of the mouth of Glacier Creek on the north side of the river and claims on the south side of the river about 4 miles below Glacier Creek, and the second to prospecting ground on Contact Gulch opposite the mouth of Toby Creek. A large number of claims have been staked, including practically all of the limestone-greenstone contact, but some of them show nothing but the green carbonate stain.

Glacier Creek, among the tributaries of Chitistone River, is at present the area of greatest promise. Native copper is the ore chiefly found.

The property of the Houghton Alaska Exploration Company west of Glacier Creek on Chitistone River on which most work has been done lies at the limestone-greenstone contact 1,225 feet above the river valley. A tunnel 20 feet deep follows a fault in the limestone, running S. 30° E. and dipping 70° to 80° E. This tunnel lies just above the greenstone contact, at the top of a large limestone talus slope. Fifteen feet higher and 20 feet farther east is a slope about 25 feet long driven on the dip of a fault parallel to the bedding, which strikes N. 60° E. and dips 35° S. There is a fault zone of crushed country rock which has a thickness of 4 feet on the west side of the slope but diminishes to 2 feet on the east side and practically dies out at a short distance from the mouth. It can be followed for 15 feet westward and is then cut off by a cross fault, giving it a lenticular cross section with a maximum thickness of 4 feet and a length of about 25 feet. The limestone is further cut by many small calcite veins. The fault zone is heavily impregnated with blue and green copper carbonate, accompanied by epidote. Iron oxide also is abundant in the crushed zone. The copper minerals penetrate the country rock, coating the joint planes with green carbonate, but azurite is almost restricted to the crushed zone.

The central camp of the Alaska United Copper Exploration Company is at the mouth of Contact Gulch, opposite Toby Creek, and most of the summer's work was done in that vicinity, although the company owns many other claims. A large part of the season was consumed in the construction of a cabin and trails by which the prospects, situated over 2,000 feet above the mouth of Contact Gulch, may be reached. Bornite in greenstone is the principal ore, but not enough development has yet been done to reveal any large body of it.

GLACIER CREEK.

Native copper is found on Glacier Creek in a small gulch about 1 mile above the lower end of the glacier, or 6 miles above the mouth of the creek. This copper was known to the Indians, who broke out fragments from the bed rock. The outcrop is on the northwest side of a steep gulch 625 feet above the glacier and less than half a mile from it. The gulch is reached by a trail over a high rock cliff, by going along the north side of the glacier between the ice and the bank or by crossing diagonally from the south side of the glacier. Traveling along the glacier's side is dangerous because of almost continuous rock slides and is not possible at all in some seasons.

The country rock is a series of bedded amygdaloidal greenstone flows, and the copper is seemingly restricted to a particular one of these beds. Nearly 75 feet above the creek, on the claim known as the Chiti, the greenstone is cut by a fault running N. 10° E. and dipping 40° W., almost parallel to a bed of greenstone filled with black amygdules and cut by small veins of the same material. Above and below this bed, whose maximum thickness is 8 feet, is greenstone with quartz amygdules and only a small amount of the black mineral. In the main open cut the fault appears at first glance to form the hanging wall, but there is a small thickness, not over 2 feet, of the black amygdaloidal greenstone just above it. Thirty feet farther north along the strike the fault is at the foot wall, and here the black amygdule rock has its greatest thickness, 8 feet. The main fault changes its direction here and strikes more nearly east and west. It is cut by minor faults and slightly displaced. The black amygdule rock is covered by slide rock 50 feet south of the largest cut, but continues with decreasing thickness northeastward for about 200 feet. The large fault, however, is easily traced for not less than 300 feet.

Copper is present as malachite, native copper, chalcocite, and cuprite. Masses of native copper weighing several pounds are found, but it is present chiefly as small specks in the greenstone and the black amygdules and as thin sheets or leaves of about the thickness of paper and small stringers in the greenstone. The larger masses occur in sponge or net-like form inclosing country rock. The largest one seen in place was not over 8 inches in diameter, but a quartz vein 300 feet north of the main cut yielded a mass weighing about 60 pounds. The fault with traces of the black amygdaloidal rock and some copper are reported to be found still farther northeast, but were not followed.

DAN CREEK.

Dan Creek is the first tributary to Nizina River below the Chitistone, from which it is separated by a mountain mass made up of Nikolai greenstone capped by gently northward-dipping Chitistone limestone. On the northern side of this mountain mass the limestone-greenstone contact at its lowest point is only a few hundred feet above Chitistone River. On the southern or Dan Creek side, however, it ranges from 2,000 to 4,000 feet above the stream. A further description of the geography and geology of Dan Creek is given in the account of its gold placers, a few pages beyond.

Just below the contact, north of Dan Creek, the greenstone in many places is stained with copper green and contains small stringers and bunches of copper minerals, chiefly bornite. This is said to be particularly true of a zone of greenstone extending for a long distance along the contact and situated about 30 feet below it.

At the head of Boulder Creek, which joins Dan Creek below the canyon, is a claim called the Westover, belonging to the Alaska United Copper Exploration Company. The exposed ore is a mass of bornite at or just above the limestone-greenstone contact. This ore body is entirely in the limestone and is unusual in that the other known similarly situated copper deposits of the eastern portion of the Chitina copper region are chalcocite rather than bornite. The surface exposure has a length, in a horizontal direction, of 30 feet and a maximum width of 8 feet. At one end the ore consists of nearly pure bornite whose boundaries with the inclosing limestone are rather sharply defined. At the other end it gradually fades into the country rock. No development work has been done other than to clear away the face of the exposure.

THE NIZINA GOLD PLACERS.

LOCATION AND HISTORY.

The Nizina placer district, as now known, embraces in a general sense the drainage areas of Dan, Chititu, and Young creeks, which flow into Nizina River from the east and south. Young Creek empties into the Nizina about 20 miles above its mouth, Chititu Creek comes in about 1 mile above Young Creek, and Dan Creek flows into the main river about 4 miles farther upstream.

The discovery and location of these placers in 1902 has been described by Mendenhall and Schrader.[a] After passing through the stampede stage of exploration, the Nizina district relapsed into a period during which a great many of the claims as originally located were worked only on a small scale in an unprofitable manner. From one cause or another much of the better ground was soon involved in lawsuits that have taken until last year to settle in a way to justify systematic work necessitating an investment of capital.

GEOLOGIC SKETCH.

The bed-rock floor of this area is, so far as known, made up of a series of shales with a few thin limestones that are rather commonly intruded by dikes and sheets of light-colored porphyry. This bed rock on Chititu and Dan creeks is for the most part a dark, fine-grained homogeneous shale in which there is very little limestone. These shales are hard and closely jointed and have been intricately folded and contorted. They have also been subjected to faulting, some of which is very recent, as it has occurred since the unconsolidated Pleistocene bench gravels that lie unconformably upon the shales were deposited. It is probable that this shale bed rock is the floor upon which rests the thick sheet of bench-gravel deposits that, so far as known, appear to extend from the northern slopes of the valley of Dan Creek along the gently sloping mountain sides that form the eastern side of the Nizina Valley to and probably beyond Young Creek. Schrader and Spencer represent the higher mountains to the east to be made up of this series of shales and thin-bedded limestones.

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[a] Mineral resources of the Mount Wrangell district, Alaska: Prof. Paper, U. S. Geol. Survey No. 15, 1903, pp. 59–61.

The unconsolidated deposits of the region that concern this paper include bench and stream gravels. Of these two the bench gravels are of less present commercial importance, although in amount they greatly exceed the stream deposits. The general distribution of this thick gravel terrane appears to correspond to the benchlike surface feature that extends along the eastern side of the Nizina Valley from Dan Creek to Young Creek and beyond in a southwesterly direction. The gravels apparently have their upper eastward limits about the middle altitudes of the mountain sides. They gradually slope down toward the west to an elevation of about 3,000 feet above sea level, where the surface descends more abruptly for several hundred feet and thence continues on to the west for 2 to 6 miles as a gradually sloping valley floor to Nizina River, where the elevation is about 1,400 feet.

It is not known to what extent the configuration of the surface of the rock floor buried by this thick mantle of gravels may influence their distribution, but there are undoubtedly considerable irregularities both in slope of surface and in surface forms, as ridges, valleys, and hills such as would be presented by a rolling topography of moderate relief, that have been controlling factors in the original distribution of the gravels. This consideration of the older rock-floor topography is especially important in studying the Nizina placers for the reason that at the present time all the evidence points toward the bench gravels on this older land surface as being the source from which the supply of gold in the present stream or creek gravels is chiefly derived.

The view that the easily worked creek gravels of the present streams have received their gold from a source in the higher bench gravels is amply substantiated by the fact that the presence of gold in the bench gravels has been established. On Chititu Creek the bench gravels have been prospected rather carefully and systematically at several localities by digging tunnels into their lower part along their contact with the underlying shale bed rock, and it has been found that gold is present in no inconsiderable amount and that although the values are naturally highest on or near bed rock, yet there is a considerable amount of gold distributed in the gravels for some distance above bed rock. Under present conditions, however, it does not seem that the bench gravels can be worked profitably for their gold content. When supplies and labor can be obtained at lower cost, it may prove profitable to mine these bench gravels by tunnel and drift methods along the bed-rock surface or possibly by hydraulicking on a large scale. These bench gravels are not frozen, as are similar deposits in some parts of Alaska; consequently in working them by tunnels and drifts it is necessary to timber the workings thoroughly, an item of expense that increases the cost of such operations. It is by no means improbable that there may be old channels in the rock floor underlying these gravels, where placer gold has been concentrated in amounts large enough to pay for mining by timbered tunnels and drifts. It may also be found that over some areas the bench gravels are not too thick to be profitably worked by hydraulic methods, even if a considerable thickness of barren overburden should have to be removed to reach the pay ground. It is possible that a systematic and thorough sampling of large areas by drilling test holes is the best manner by which this problem of the bench gravels may be approached.

The present stream gravels of Dan, Chititu, and Young creeks are the deposits in which gold was first discovered and on which active operations are now being conducted. They are in part derived from the bench gravels and in part by the cutting of the streams in their own bed-rock channels. These deposits are more fully described in connection with the individual creeks.

The suggestion that the present auriferous creek deposits were evidently derived from the thick mantle of bench gravels leads to the question as to the source of the bench gravels and the placer metals they contain. Greenstone bowlders, cobbles, and pebbles form a characteristic percentage of the material of the bench gravels. Another characteristic feature is the presence of considerable native copper in the form of nuggets. A few of these copper nuggets weigh more than 100 pounds, but most of them run about 1 or 2 ounces. The nearest known source for the greenstone and native copper of these gravels is on the north side of the valley of Dan Creek and thence northward in the area of Chitistone River. Here there are areas of greenstones in which some small amounts of native copper are known to occur, but no gold has been reported from these rocks. The following statements are quoted from the report by Mendenhall and Schrader:[a]

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[a] Mendenhall, W. C., and Schrader, F. C., Prof. Paper U. S. Geol. Survey No. 15, 1903, p. 61.

> The rocks throughout the greater part of the district are reported by Schrader and Spencer to be the black shales and thin limestones of the Triassic, but in the northern part of the basin of Dan Creek the Nikolai greenstone and the overlying heavy-bedded Chitistone limestone outcrop. There is a doubtful region about the head of Young Creek where these older rocks may also be found.
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> The black Triassic shales are reported to be intruded in this region, as they are known to be in other localities, by abundant porphyritic dikes, and the gold may be found to be genetically connected with these intrusives.

So far no facts have been brought to light to show whether the porphyry dikes in the Triassic shales may be a possible source of gold or not. On the other hand, it has been reported by a prospector that placer gold occurs in the conglomerates of the Kennicott formation in this region. This formation has been assigned to the Upper Jurassic or Lower Cretaceous, and at present the only rocks of this age known to occur in the Nizina placer area lie south of Young Creek. There is also an area on the west side of Nizina River, opposite the mouth of Chitistone River. The Kennicott formation as now known occurs in isolated areas, of no very great extent, distributed from Kotsina River to the mountains south of Young Creek. It lies unconformably upon the Triassic shales and limestones and older greenstones. This series of conglomerates was no doubt formerly very much more widely distributed than it is at present. Extensive deposits of it have probably been entirely carried away by erosion, and if they were gold bearing in part or as a whole it can easily be seen how such a source might have supplied the present bench gravels in the Nizina district.

CHITITU CREEK.

The stream gravels of Chititu Creek and its tributaries are the deposits that have received the most attention in this district. The upper half of Chititu Creek occupies a comparatively narrow valley that is excavated to a depth of 200 to 400 feet through the thick deposits of bench gravels to the shale rock floor beneath. In this shale bed rock the stream has carved a trough that conforms in slope to that of the surface of the rock floor. In width this trough ranges from 200 to 700 feet and its depth is from 10 to 50 feet. It is well filled to a depth of 8 to 16 feet throughout its length and width by recent stream gravels. These gravels have been mostly derived and concentrated from the bench gravels in which the creek valley has been excavated. In brief, the whole process has been that of a natural ground sluicing of the bench gravels down to the grade of the shale rock floor, in which a natural bed-rock flume has been cut. This bed-rock flume has been paved with the bowlders and larger cobbles of the bench material and has thus afforded a natural set of riffle blocks that have served to catch and hold the gold and copper which make up the metal values.

Only one of the original locators of claims on Chititu Creek has developed his holdings along conservative and consistent lines from the time of their discovery. On claim No. 11 above Discovery open-cut work was begun with pick and shovel. This was facilitated the next season by the use of canvas hose, and finally a small hydraulic plant with giants was installed. This plant has been improved from year to year and the results obtained have been increasingly satisfactory to the owner.

In 1907 active development work was begun on a group of claims that includes the major portion of the placer ground on Chititu Creek. A complete hydraulic plant, supplemented by a well-equipped sawmill run by water power and an electric-lighting plant to aid in night work during the latter part of the open season, was during the winter taken over the snow and ice to Chititu Creek from Valdez, a distance of 200 miles, by means of horses and sleds. This winter method of transportation is the only way by which any considerable quantity of materials can be conveyed into the Copper River region at the present time. Even when economically conducted, on a large scale involving quantities of 100 tons or more, such transportation from Valdez to the Nizina district has never cost less than $130 per ton. On small amounts of supplies the cost may be as much as $400 per ton.

The greater part of the open season of 1907 was spent in installing this plant on the lower eight claims on Chititu Creek. The sawmill was erected on claim No. 4 above Discovery to supply lumber for flumes, buildings, and other purposes. A large amount of hydraulic pipe was riveted together from the separate sheets, and as the season progressed the whole plant with dam and head-gates on claim No. 8 above, the flume and pipe lines, lighting plant, etc., was assembled in working order so that by the close of the season all arrangements were completed for beginning active mining on claim No. 1 with the opening of the season of 1908.

DAN CREEK.

Dan Creek in point of size is the first important tributary to Nizina River above Chititu Creek and, as has been previously stated, is also the first one below Chitistone River. Its general course is west-northwest and it joins the Nizina at the point where that stream, flowing southward from the Skolai Mountains, abruptly changes its course to the west. The drainage area of Dan Creek covers approximately 45 square miles and is nearly as broad as it is long.

The stream for a distance of nearly a mile below the place where it emerges from the mountains flows across the gravel floor of the Nizina River valley, but is raised slightly above it by the broad, low, fan-shaped deposit of gravels it has brought down from above. The valley above this portion of the stream presents three different topographic features. For nearly 2 miles Dan Creek has cut its way through the deep bench gravels bordering the Nizina Valley and has excavated a shallow trough in the country rock. In this narrow trough the stream gravel is laid down. Above this portion the channel is in a narrow box canyon, which finally expands into the more open, basin-like upper valley. Two principal branches unite above the canyon to form the main stream. The northern branch retains the name Dan Creek; the other is known as Copper Creek.

The bed rock as naturally exposed or as uncovered by mining operators along the lower part of Dan Creek is made up of Triassic shales intruded by light-gray porphyritic and greenstone dikes. These shales, so far as is now known, occupy most of the area south of Dan Creek to Chitina River. North of Dan Creek is the Nikolai greenstone, overlain by a heavy capping of Chitistone limestone that forms the top of the mountain mass between Dan Creek and Chitistone River. The unnatural position of the Triassic shales south of the stream with reference to the greenstone north of it is believed to have been brought about by a great fault extending through the valley from southeast to northwest and removing from view the Chitistone limestone, which normally should be present between the greenstone and shales. This fault continues northwestward at least as far as Lakina River.

Placer mining is at present restricted to the regions above and below the canyon. Above the canyon the most work has been done on Copper Creek. This part of the stream is difficult to reach with supplies and only a few men were at work there in 1907. Most of them were doing nothing but assessment work, and yet a few thousand dollars in gold have been produced during the several years since work began. The creek claims below the canyon are under one control, and though the gold production has not been large, owing to the difficulty of working the ground, prospecting has shown that gold is present.

Placer gold is associated with two classes of deposits—the present stream gravels and the older and much more extensive bench gravels. Mining or prospecting has been carried on in both of these. Undoubtedly a great part of the gold in the present stream is a concentration from the benches through which the creek has cut its channel. Whether any part of it has been brought by the present stream directly from its original source or a source other than the higher unconsolidated bench gravels to the place it now occupies is a question whose answer was not determined.

The first claim below the canyon is No. 7 and the numbers decrease down stream. Near the camp a cut approximately 400 feet long and as wide as the shovelers could work at one setting of the boxes was made in the creek gravels of claim No. 5. Directly above is a larger cut, nearly as long and averaging about 75 feet in width. The bed rock is hard, close-jointed shale cut by dikes of light yellowish-gray porphyry and of greenstone. The gravel and its slight soil covering range in thickness from 8 to 12 feet. The gravel consists in part of shale fragments and contains a large percentage of greenstone and porphyry. Some of the bowlders in the large cut have diameters as great as 4 feet, and many of them average 10 or 12 inches in maximum diameter. All of this material has been more or less rounded by stream action. It is poorly bedded and spruce logs and fragments of wood are buried in it. The large cut was made by piling up a wall of bowlders along the gravel face, thus forcing the creek water to undercut the bank and causing it to cave. Bed rock was then cleaned by hand. Such work is expensive, as it requires several handlings of all the larger material. A third cut, 300 feet long and one box wide, on claim No. 6, showed gravel and bed rock of the same character.

The width of the stream gravels is not great, in places not over 100 or 200 feet, but increases as the creek is descended. On either side benches of gravel close to the stream rise to a height of several hundred feet. Tunnels in these benches have demonstrated that they carry gold. One of these tunnels on the upper end of No. 6 or the lower end of No. 7 had a length of 72 feet. It was driven along the rock floor upon which the gravel rests and is 10 feet higher than the present stream. In other words, the creek here has cut 10 feet into the bed rock since the present drainage was established. The tunnel was driven in winter as a prospect and yielded good values in gold.

The Dan Creek gold from the gravels below the canyon is coarse and smooth. Most of it is flat, and the heaviest of it is found either on bed rock or within 2 feet of it. It is accompanied by placer silver and placer copper. Nuggets of silver and copper, such as are called "half breeds" in the Lake Superior region, are frequently found here, and on Chititu Creek also. Copper is associated with both the creek and the bench gravel, in pieces ranging from the size of shot to masses of 100 pounds or more. It is only recently that any effort has been made to secure the copper, as it is of no value with the present means of transportation. Most of the operators are now saving it, however, and when railroad transportation is available the returns from the copper may be found to reduce considerably the cost of mining.

The gold from Dan Creek above the canyon differs from most of that below in that it is generally rough and not flattened, indicating that it has not been hammered out and worn so much by moving bowlders.

Surveys for a hydraulic plant on the lower end of Dan Creek have been made, and it is expected that the plant will be installed during the summer of 1908.

NOTES ON COPPER PROSPECTS OF PRINCE WILLIAM SOUND.

By FRED H. MOFFIT.

The copper prospects of Prince William Sound were examined by U. S. Grant and Sidney Paige in 1905 and a short account describing the general geology of the region and the occurrence of the copper ores was published.[a] Since that time the region has not been visited by members of the United States Geological Survey, but the statements here made concerning later developments have been procured from sources that are believed to be reliable. A small map of the region (fig. 2) is here reproduced without change from Grant's preliminary report.

During the two years since 1905 two mines have made regular shipments of ore to the smelter, several promising prospects have been partly developed, and further prospecting has been carried on in all parts of the sound. The search for copper has been active on Knight Island, Latouche Island, and in the vicinity of Copper Mountain and of Orca. Attention has been directed most strongly toward Knight Island and considerable money has been expended in the endeavor to prove the presence of ore bodies of commercial value, but it can not be said that a copper mine has yet been developed there. Shipments of ore have been made from prospects in various parts of the sound, but most of them must be regarded merely as smelter tests and give no indication of the ability of the prospects to produce ore regularly and in quantity. This statement is made because one or two companies are said to have purposely endeavored to misrepresent the state of their development work or the value of their ore deposits by reports of this kind.

As described by Grant, the geology of the region may be briefly summarized. The rocks of Prince William Sound are in part sedimentary, in part igneous. The sedimentary rocks consist essentially of graywackes and slates, the graywackes in places approaching arkoses and sandstones or even quartzites. The color of both graywackes and slates is dark gray or black, the slates being the darker. Limestones are few and inconspicuous.

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[a] Grant, U. S., Copper and other mineral resources of Prince William Sound: Bull. U. S. Geol. Survey No. 284, 1906, pp. 78–87.

Granite, aplite dikes, basic dikes, and basic lava flows constitute the igneous rocks. Only the basic lava flows are of special importance in connection with the copper deposits. These flows are more or less altered and in places are schistose. They are usually referred to as greenstones.

Sedimentaries and interbedded lava flows are much folded so that bedding and cleavage are in most places parallel. The sedimentary rocks of Prince William Sound consist of two series of nearly similar beds that have been given the names Valdez and Orca. Of these the Orca is more widespread and differs from the Valdez in being a little less metamorphosed and in containing much black slate, conglomerates, and many interbedded lava flows.

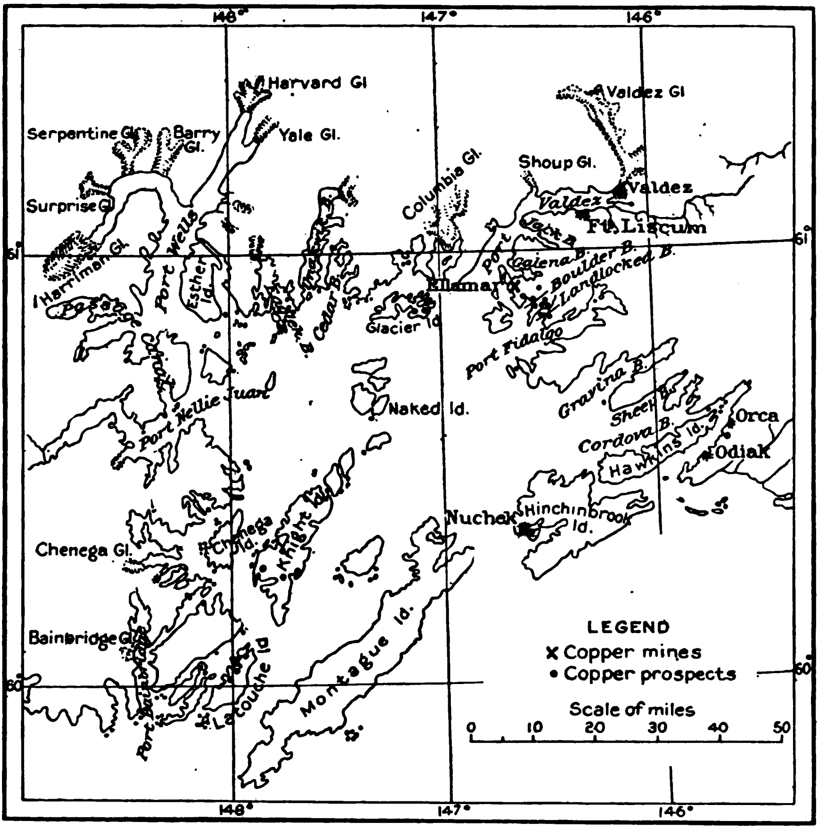

FIG. 2.—Sketch map of Prince William Sound. By U. S. Grant, 1905.

The copper ores are chiefly chalcopyrite, generally associated with pyrrhotite and less commonly with pyrite and marcasite. It occurs in many places in shear zones in greenstone, and this association of copper ore with greenstone is so pronounced that the copper is believed to be derived from the greenstone. Native copper and chalcocite have been found in the vicinity of Orca in sufficient amount to indicate a possibility of their commercial importance.

Among the older and better-known properties that at Ellamar was partly idle during the summer, it is said because of labor troubles. The shaft was sunk to the 600-foot level and 650 feet of drift was made. At Galena Bay an aerial tram 5,000 feet long, from the mine to the beach, was begun and ore bunkers were being constructed at the beach. Only a small amount of work was done at Boulder Bay, most of it by the Reynolds-Alaska Development Company, which extended its main tunnel. Some small shipments of ore were made from Landlocked Bay and a tramway and wharf were built.

The Beatson property at Latouche, known as the Bonanza, but not to be confused with the Bonanza mine on Kennicott River, in the Chitina region, was the only property of western Prince William Sound to make regular shipments. A crosscut tunnel 900 feet long was driven, cutting the ore body at a level 90 feet below the old tunnel. The Reynolds-Alaska Development Company has erected a wharf, electric-light plant, trading store, and a number of houses on its property at Horseshoe Bay, on the west side of Latouche Island. A shaft was sunk on one of the claims and a small amount of ore was shipped. East of the Bonanza mine, on the Barrack claims, active development work was in progress. A wharf, ore bunkers, and a tramway were under construction and a little ore was shipped.

A great many claims have been staked on Knight Island, but most of the locations were made within a year or two so that development work is not as far advanced as on some of the older properties. Among those most actively engaged in prospecting is the Hubbard-Elliott Company, whose property is located at Drier Bay, on the west side of the island. A tramway with other equipment was installed during the summer and a small shipment of ore is reported.

Prince William Sound properties enjoy a great advantage over those of the interior in that nearly all of them are within comparatively easy reach of tide water and their development is not dependent on expensive railroad construction or hindered in the same degree by the severity of the winter.

OCCURRENCE OF GOLD IN THE YUKON-TANANA REGION.

By L. M. Prindle.

INTRODUCTORY STATEMENT.

The placer-gold production of the Yukon-Tanana region up to 1907, inclusive, has been approximately $33,500,000, or nearly one-third the total gold production of Alaska; of this amount over two-thirds has been contributed by the Fairbanks district. The importance of this region has led to comprehensive work by the Geological Survey. The mapping of the region, commenced in 1898 by the mapping of the Fortymile district, has been carried on continuously since 1903, until at the present time the greatest part of it has been mapped on a scale of 1:250,000, or about 4 miles to the inch. Geologic work of a reconnaissance nature, commenced by Spurr, Goodrich, and Schrader in 1896,[a] has also been carried on continuously since 1903, and a body of material has been collected that has not yet been thoroughly studied. The following statements, therefore, being based on a very superficial study of the data, have only provisional value. A map (Pl. IV) has been prepared to show the distribution of known gold placers, of the main rock groups of sedimentary origin, of intrusive rocks so far as they have been approximately delimited, and of recent volcanics.

BED ROCK.

The rocks of sedimentary origin in this region include essentially two groups—one of metamorphic, complexly folded schists provisionally assigned to the pre-Ordovician, and another, supposedly in unconformable relation to the schists, of phyllites, greenstones, quartzites, and limestone belonging to the Silurian, Devonian, and Carboniferous. Besides these two groups there are areas of Lower Cretaceous slates along the Yukon, Upper Cretaceous sandstones and shales in the Rampart region, and several areas of Tertiary clays, lignites, sandstones, and conglomerates.

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[a] Spurr, J. E., and Goodrich, H. B., Geology of Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 87-392.

Igneous rocks are present as intrusives and extrusives. There are many large areas of intrusive rocks in the eastern part of the region, and the portions of them that have been traversed are indicated on the map (Pl. IV). Isolated areas are scattered throughout the region and there are probably many more than are shown on the map. These rocks range in composition from acidic granite to peridotite. Granitic rocks and those of intermediate composition are most common. Some of the granites have been metamorphosed to granitic gneisses and have been intruded by later granites. The only age of intrusion that has been definitely established is that of rocks of intermediate composition in the vicinity of Rampart, where Paleozoic rocks and Upper Cretaceous sandstones have been intruded. The greenstones of Paleozoic age are largely altered diabasic and basaltic flows.

Areas of fresh volcanic rocks are indicated in the eastern part of the region, where they occur generally as masses capping the hills of schist or as plugs with a surrounding mass of volcanic material. In one place they occur as a small volcanic cone. The composition of the volcanic rocks parallels that of the intrusives to a certain extent; there are rhyolitic, andesitic, and basaltic types. The latest volcanic rocks are believed to be at least post-Tertiary and are possibly of Quaternary age.

ALLUVIAL DEPOSITS.

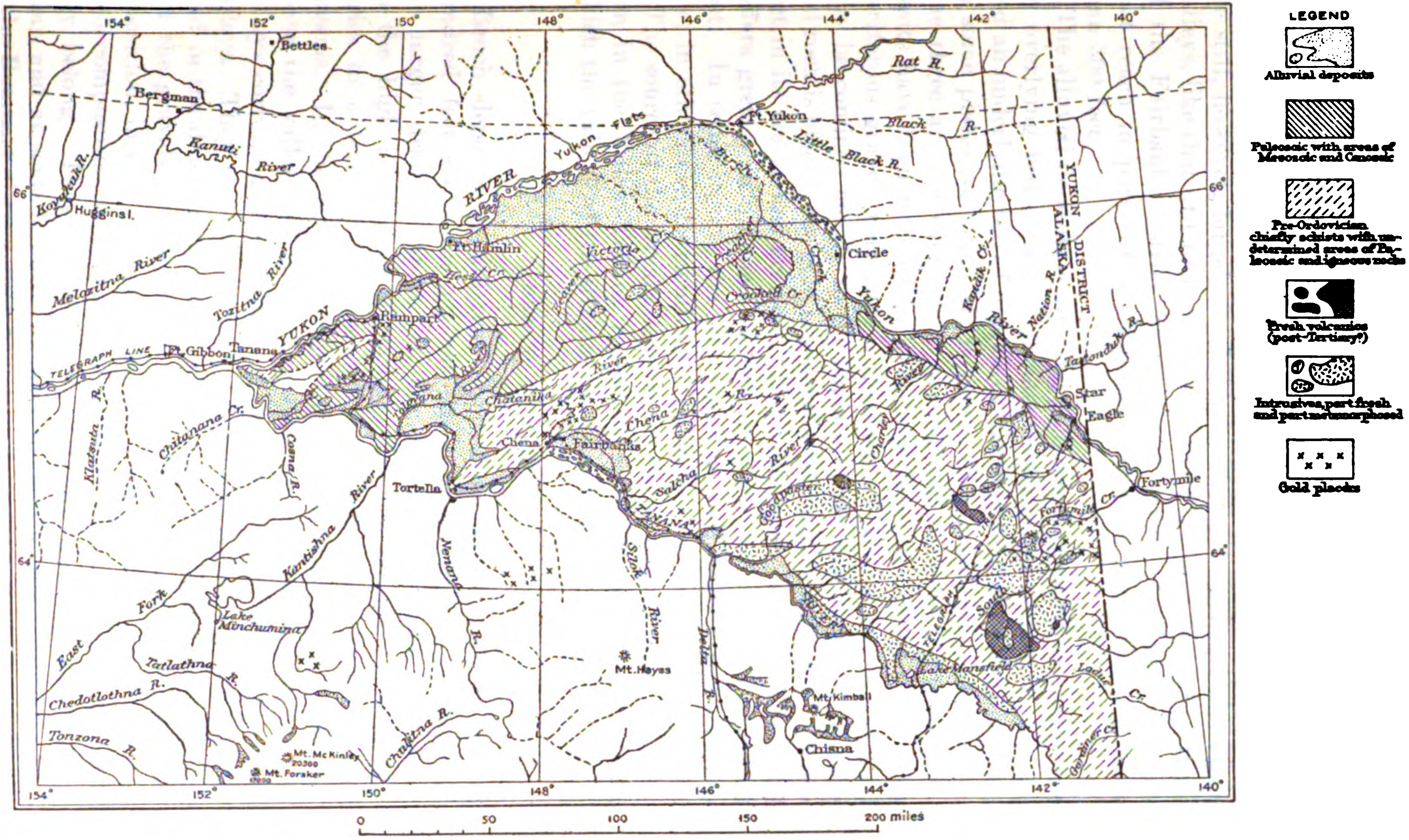
GENERAL CHARACTER.

The alluvial deposits comprise silts, sands, and gravels of Pleistocene and Recent age, and these are partly auriferous. The Fortymile, Birch Creek, Fairbanks, and Rampart districts have up to the present time produced most of the placer gold, but intervening areas have also proved somewhat productive and the causes of mineralization have evidently been in operation over a large part of the region. Though the alluvial deposits have furnished practically all the gold that has been produced, a few localities have been found where gold occurs in the bed rock.

The alluvial deposits containing gold include chiefly the present stream gravels and the bench gravels related to the valleys of these streams. Most of these deposits are frozen throughout the year. It is possible, also, that some of the Tertiary conglomerates have contributed a small part of the alluvial gold.

STREAM GRAVELS.

The extent and thickness of the stream deposits vary greatly in different valleys. Narrow valleys, like that of Franklin Creek in the Fortymile district or the upper part of Deadwood Creek in the Birch



GEOLOGIC SKETCH MAP OF YUKON-TANANA REGION.

Creek district, have a narrow deposit of gravels sufficiently shallow to be worked almost entirely by open cuts. Wider valleys, like those of Wade and Mastodon creeks, have wider and thicker deposits that are still, however, largely workable by the open-cut method. Open valleys, like that of Chicken Creek in the Fortymile district or those of the Fairbanks district, have a great extent of alluvial deposits that reach in parts of the Fairbanks district a thickness of more than 300 feet.

The alluvial deposits containing gold are, in general, separable into an overlying bed of muck, an intermediate bed of barren gravels, and an underlying bed of gravels containing the gold. These beds are in some places well defined; in others they grade into one another. The three are not everywhere present and some of the stream deposits have been invaded by slide rock from the valley sides. The auriferous gravels may have a thickness of several feet or the gold may be confined mostly to the surface of the bed rock. Where the bed rock is blocky, the gold is generally found also to a depth of a few feet in its cracks and crevices. The width over which gold is found differs greatly in different valleys; in some it is several hundred feet. In some valleys the pay streak is well defined and continuous; in others the distribution of values is very local and irregular.

The source of the stream deposits, in the absence of general glaciation in the Yukon-Tanana region, is referable to the bed rock in which the valleys of the streams have been cut.

BENCH GRAVELS.

Bench deposits at different levels from a few feet to several hundred feet above the present streams are common in many of the larger drainage areas. In the Fortymile district they occur on the high benches of Fortymile Creek and some of its tributaries to a level of at least 300 feet above that of the present streams. In the Rampart region there are bench gravels 500 feet above the valleys. The bench gravels occupy positions in the old valleys corresponding to those of the stream gravels in the present valleys. They are the remnants of the old valley deposits left behind in the downward cutting of the streams to their present level, and the gravels at different levels mark the pauses, with attendant deposition, in this process. Like the stream gravels, they reflect in their composition the character of the bed rock in the valleys to which they belong. They are of widely differing thickness in different areas, and at some localities, notably in the Chicken Creek area and in the Rampart district, they have been found rich in gold.

AURIFEROUS CONGLOMERATES.

Conglomerates regarded as Tertiary occurring in the Yukon-Tanana region are so much older than the stream and bench gravels that the conditions of their formation are obscure. The gravels forming them, however, were probably deposited under fluviatile conditions associated with or subsequent to lacustrine conditions, and since their deposition have been consolidated and folded. These rocks form a well-defined belt in the area between the Seventymile and the Yukon and westward toward Circle. The gravels of several creeks draining this area contain gold and have been mined for several years. Their gold content is regarded by Brooks[a] as evidence of the presence of alluvial gold in the conglomerates.

ORIGIN OF GOLD.

All the available evidence regarding the origin of the placer gold in the Yukon-Tanana region indicates that it has not been deposited in the placers from solution, but has been derived with the other constituents of the gravels by mechanical separation from the bed rock. Inasmuch as the material forming stream and bench gravels is definitely referable to the bed rock of the respective valleys, those auriferous valleys where there is the least variety of bed rock should throw some light indirectly on the origin of the gold. Furthermore, the immediate associates of the gold, or, better still, adherent pieces of other mineral or rock, bear definitely on this problem. If in addition to these indirect sources of information, localities can be cited where gold occurs in place in the bed rock, a considerable body of material will have been assembled that should prove illuminative of at least some phases of the origin of the placer gold.

There are few creeks in the Yukon-Tanana region where the geologic conditions are relatively simple. The variety of bed rock of sedimentary origin is further complicated by the intrusive rocks that are locally present in all the important placer-mining areas. Under what are apparently some of the simplest conditions, however—those on Wolf Creek in the Fairbanks districts, where the bed rock observed in the amphitheatral area at the head of the creek is quartzitic schist and quartz-mica schist with small quartz veins and where the gravels so far as observed are of the same material—the rough, gritty gold, some of it with quartz attached, must have been derived from the schist and most likely from quartz stringers cutting it. The conditions of origin are apparently the same in Fairbanks Creek, heading on the opposite side of the same ridge. On Harrison Creek, in the Birch Creek region, where the same bed rock prevails, a slab of similar schist was found in the gravels containing a gold-bearing quartz seam. This occurrence was described by Spurr.[a] A similar association has been observed on Davis Creek, in the Fortymile region. The fact seems definitely established that in some of the most productive regions a part of the gold, at least, has been derived from the quartz veins in the schists, and as these schists are the most common rocks in the Fortymile, Birch Creek, and Fairbanks districts, it is probable that a large proportion of the gold has had this origin. That the mineralization of the schists has not been confined to the deposition of gold is shown by the facts that in the Fairbanks district stibnite (sulphide of antimony), cassiterite (oxide of tin), and bismuth have been found in association with the gold in the placer deposits and that veins of stibnite have been found in the schists.

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[a] Brooks, A. H., Report on progress of investigations of mineral resources of Alaska in 1906: Bull. U. S. Geol. Survey No. 314, 1907, pp. 198–200.

Rocks regarded as Paleozoic are present in the Fortymile district and some of the gold occurrences are referable to these rocks. The same is probably true of the Rampart district, where the rocks are predominantly Paleozoic but where there are also pre-Ordovician schists and a few Mesozoic rocks of Upper Cretaceous age. In the Rampart region native silver is a common associate of the gold on some of the creeks, and native copper is also found.

The metals and minerals associated with gold in the placers of the Yukon-Tanana region include lead, silver, copper, bismuth, argentite (silver sulphide), stibnite (antimony sulphide), galena (lead sulphide), cinnabar (mercury sulphide), iron pyrites, copper pyrites, barite, cassiterite (tin oxide), rutile, garnet, magnetite, hematite, and limonite.

On creeks tributary to the Yukon a close relation has been observed by Brooks between the alluvial gold and Lower Cretaceous slates. and the following is quoted from his report:[b]

> The rocks exposed along the Yukon between Eagle and Circle do not anywhere include any of the older schists, such as are associated with the Birch Creek placers. In fact, over much of this belt the formations are slightly altered limestones, shales, slates, and conglomerates, which do not bear evidence of mineralization and will not attract the placer miner. Locally, however, some of these rocks are mineralized and contain more or less gold. Thus on Nugget Gulch, a tributary of Washington Creek, slates of Cretaceous age are found which are permeated with quartz veins, some of which must yield gold, as the associated alluvium is auriferous. The writer was not able to study this locality, but it appears that the coarse gold occurs in small patches on the bed rock. This occurrence, though probably of small commercial import, has a far-reaching significance, as it indicates that there has been an intrusion of mineralized veins since these younger rocks were deposited. The writer is, however, of the opinion that this mineralization is not general enough to encourage the search for placers where these Cretaceous slates form the country rock.

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[a] Spurr, J. E., and Goodrich, H. B., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 353–354.

[b] Brooks, A. H., Report on progress of investigations of mineral resources of Alaska in 1906: Bull. U. S. Geol. Survey No. 314, 1907, pp. 198–199.

Gold has been found in place at several localities within the Fortymile district, and these are described briefly in the succeeding paper. At the locality on Mosquito Fork about 2½ miles from Chicken Creek the gold occurs in a brecciated mineralized zone in a quartz diorite. There has been considerable silicification and an abundant introduction of iron pyrites. At the locality near the head of Chicken Creek the gold occurs in thin calcite veins that are associated with pyritiferous quartz veins in black phyllites regarded as Paleozoic. These are in contact with quartz diorite porphyry, the marginal facies of a rock like that on Mosquito Fork. The placer gold of Chicken Creek is derived in part, at least, from a deposit of this form. At Canyon Creek there is a brecciated mass of vein quartz and quartzitic schist. The rock here is very ferruginous and locally fragments have been found containing specks of gold visible to the eye. In the Flume Creek occurrence there are numerous small auriferous quartz veins penetrating a serpentinous igneous rock that is intruded by basic dikes. Other occurrences of gold in bed rock are reported, but have not been studied by the writer.

So far as definitely known, then, at the present time, the placer gold of the Yukon-Tanana region is traceable to quartz veins in the pre-Ordovician schists, apparently also to those in the Paleozoic phyllites, and possibly to those in the Cretaceous slates; to calcite veins in rocks regarded as Paleozoic in close contact with igneous rocks; and to quartz veins and silicified areas of secondary origin in igneous rocks.

A consideration of the map shows that igneous intrusives have a wide distribution over the entire region and are present in all the chief placer-mining districts. They are also of widely differing age. The Upper Cretaceous rocks in the vicinity of Rampart have been intruded by them and mark, so far as known, the last period of intrusion of plutonic rocks in the Yukon-Tanana region. Mesozoic rocks have not been found in other areas of intrusion and it is not known how many of the areas of fresh igneous rocks of granitic and intermediate composition are referable to this period. It is probable, however, that a large proportion of them were intruded at this time. Some of the granitic rocks and schists are cut by fresh basaltic dikes and the areas of fresh volcanic rocks attest the continuation of igneous activity. The question whether these volcanic rocks have taken part in the mineralization of the region has not been answered.

There are several hot springs in the region, and at least two of them are near the contact of granitic rocks with schists and with carbonaceous phyllites. The temperature of these waters is probably due to the residual heat of the igneous masses and indicates the long-continued operation of one of the factors influential in mineralization.

This region is regarded as one of large batholithic masses of intrusive rocks, now mantled by a comparatively thin shell of sedimentary rocks. Intrusions have taken place at different periods. Some of them have been accompanied or followed by numerous dikes and sills of an acidic character, and it is probable that at such times the depth of intrusion was so great as to favor, through increased pressure and temperature, a wide dissemination of the final products of the crystallizing magma through the surrounding rocks as acidic dikes and sills, as intrusive quartz veins, and finally as the ordinary quartz veins so common in the schists. Where the intrusives have penetrated to higher levels, as in the Upper Cretaceous rocks of the Rampart region, there was no opportunity for long-continued differentiation and distribution of the magma in such attenuated form and the action under such conditions has been confined to contact metamorphism and the release of the waters of intrusion to act as solvents, to mingle ultimately with meteoric waters, and to leave behind them the quartz or calcite or other substances carried in solution.

The acidic dikes and sills are very common in the Fortymile district. They have in places been crumpled and reduced to augen and exhibit generally cataclastic action. They are apparently most characteristic of the older intrusions. The occurrence of gold in the Fortymile district has not been traced directly to them, and they are not common in the Birch Creek, Fairbanks, and Rampart regions.

The intrusives of the Birch Creek, Fairbanks, and Rampart districts are comparatively fresh, and similar fresh intrusives are common in the Fortymile district. Many of these masses are surrounded by shatter zones of rock containing numerous dikes of the same material as the main mass, or a more basic marginal phase. The period of intrusion was one of great disturbance. The gold in the Chicken Creek area is in close relation with such intrusives and it is believed that in this locality at least they mark a period of mineralization accompanied by the deposition of gold derived primarily from the igneous rocks. The age of this period of mineralization is not known. The quartz veins in the Lower Cretaceous slates of Washington Creek regarded as auriferous by Brooks and ferruginous quartz veins in Upper Cretaceous rocks of the Rampart region that have been intruded by granitic rocks indicate a period of mineralization that is probably to be referred to such intrusions, and those of Chicken Creek may belong to the same period. There is as yet no direct evidence bearing on this point. The influence of igneous intrusion is far-reaching, especially in areas of such permeable rocks as siliceous schists, and in view of the widespread distribution of igneous rocks in the Yukon-Tanana region, both in space and time, and their relation to the facts at our disposal, it seems justifiable to ascribe to them the widespread mineralization of the region and to refer a part, at least, of this mineralization to the close of the Mesozoic. In this connection it is important to note the relation of mineralization to Mesozoic intrusion traced by Wright in southeastern Alaska.[a] It might be inferred, perhaps, that if the igneous intrusives have been responsible for the gold, the most productive areas should be found in the vicinity of the most abundant intrusives. Little, however, is known regarding the laws governing the occurrence of the gold in the bed rock. The composition of the intruding rock, the conditions of intrusion, and the character and physical structure of the intruded rock are among the factors in the problem. It is probable that extensive deformation at the time of intrusion, by rendering the surrounding rocks more permeable, facilitates the transportation of material from the igneous magma. It is perhaps true that in the vicinity of a cooling intrusive mass conditions favorable for solution may be maintained so long that gold derived from this source is carried in solution far into the surrounding rocks before reaching areas where conditions favorable for deposition prevail.

Some of the most productive placer areas lie within the pre-Ordovician schists and some within the Paleozoic rocks. Even in the Rampart region, where the Paleozoic rocks are abundantly developed, the older rocks are present, and the Birch Creek, Fairbanks, and Fortymile areas are not far removed from the present contact of the two groups. It seems probable, therefore, that these areas of gold deposition were adjacent to what before erosion was the contact plane of the two groups, and this plane may have afforded a favorable zone for circulating waters at the time mineralization was in progress.

SUMMARY.

So far as can be judged by present knowledge of the region, intrusion has been very general, especially in the schists, and continued to the close of the Mesozoic. Gold is very widely distributed in small quartz veins in the schists, and locally has been so abundant as to have proved richly remunerative in the associated placers. Gold is also present here and there in the Paleozoic rocks, and possibly also in later rocks, presumably in areas of intense deformation accompanied by intrusion. It has been found also in igneous rocks, where it has been introduced subsequent to the intrusion. It may be stated in conclusion that up to the present time no large body of bed rock carrying commercial values has been recognized, and that the areas of greatest and most extensive concentration in placers are in well-developed drainage systems, where there has been a long opportunity for the slow concentration of gold in the alluvial deposits.

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[a] Wright, C. W., Bull. U. S. Geol. Survey No. 314, 1907, pp. 49-51.

THE FORTYMILE GOLD-PLACER DISTRICT.

By L. M. Prindle.

INTRODUCTORY STATEMENT.

The Fortymile quadrangle includes the area between the 141st meridian, which is the international boundary, and the 142d meridian, and the 65th and 64th parallels. The area is about 70 miles long from north to south, and 30 miles wide. It produced during 1907 approximately $150,000 in placer gold. The present brief paper gives some of its salient features. A more detailed description of the district is in preparation.

Fortymile Creek crosses the southern part of the district and in this region was located the first center of gold production in the Yukon basin. The knowledge of conditions acquired there was applied effectively in other regions that were afterward developed, and these in turn are having a reactive influence. The stage of mining in which the productive unit is a mining claim is giving place to that in which the productive unit is a group of claims worked by a process correspondingly efficient. Such methods are becoming increasingly necessary to meet the conditions that now prevail. To evaluate these conditions and to determine in a particular locality the sufficiency of a mining method to meet them successfully is the problem of the mining engineer. To state very briefly the main geographic and geologic facts and the mining developments of 1907 is the scope of the following description.

Considerable work has been done in this region by the Geological Survey. It was investigated by Spurr, Goodrich, and Schrader in 1896;[a] the quadrangle was mapped by Barnard in 1898 on a scale of about 4 miles to the inch; it was traversed by Brooks in 1899; and since 1903 parties from the Survey have been mapping adjoining areas and investigating conditions in the gold-placer regions. During the summer of 1907 the writer continued his work in the region by traversing the southern portion of the area covered by the map.

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[a] Spurr, J. E., and Goodrich, H. B., Geology of the Yukon gold district, Alaska: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, pp. 87-392.

GEOGRAPHIC SKETCH.

RELIEF.

The country is one of undulating, rather even topped ridges separated by deep, relatively narrow valleys. Isolated domes rise above the general level of the ridges, which are locally of considerable prominence. Glacier Mountain attains 6,000 feet above sea level. The level of the Yukon at Eagle is about 800 feet. In general, the ridges are from 1,500 to 2,000 feet above the streams.

DRAINAGE.

The drainage of the northern part of the quadrangle is directly to the Yukon; that of the southern part to Fortymile Creek. Yukon River, crossing the northeast corner of the area, receives from the west Seventymile, Mission, and Boundary creeks. Fortymile Creek is a powerful stream and receives many important tributaries that have their sources far outside of the area covered by the map. There is considerable difference in valley development, but in general the valleys of the smaller streams are similar. Most of the larger streams have formed valley floors a few hundred feet in width. Benching is prominently developed in the larger valleys throughout the region at different levels, from a few feet to over 300 feet above the present streams. The Fortymile Valley is an example of the canyon type. The stream is deeply sunk and is still cutting downward, and the lower valleys of most of its tributaries are also narrow canyons. The streams in general head at about the same level and are cut to about the same depth. Any undertaking, therefore, involving water supply requires most careful preliminary measurements of available water and grades.

CLIMATE AND VEGETATION.

There are a few aspects of the climate that have an important economic bearing. The Yukon closes to navigation at dates ranging in different seasons from about October 10 to November 20 and does not open till dates ranging from about May 10 to May 20. Much of the ground is permanently frozen to bed rock and requires special treatment. Notwithstanding the extreme cold, there is much free water in the ground during the winter, and in many streams the water breaks through the ice already formed, causing overflows, which, although quickly frozen, are often a source of trouble and delay in travel. Constant repetition of this process throughout the winter results in the formation of thick deposits of ice in some of the smaller valleys, and these may linger till late in summer, thus further shortening the working season. Dams and other improvements are sometimes buried beneath such accumulations of ice and damaged beyond repair. This glaciering of streams is characteristic of the region, and must be taken into consideration in planning work.

The timber resources are moderate. Spruce grows abundantly in the valleys of the larger streams and is sparsely distributed over the hillsides throughout the area. It has been used generally for sluice boxes and to some extent for dredge building, the largest timber available for this purpose furnishing logs 12 to 15 feet long and a foot in diameter. Birch is common in some of the valleys, but is of minor importance. Timber for fuel is still abundant.

TRANSPORTATION.

Transportation to the creeks of the Fortymile region has always been difficult, and the situation has been rendered more complex by the presence of the international boundary with its attendant customs regulations. Most of the supplies are purchased in Dawson, Yukon Territory, and freighted up Fortymile Creek on the ice by horse sleighs during the winter months. The freighting was delayed to some extent during the winter of 1906–7 by the occurrence of glanders among the horses and by overflows to which the creek is subject. About 400 tons were shipped by this method for the dredge on Walker Fork and 100 tons for the dredge below Franklin Creek. The freight rate from Fortymile Post to the latter locality was $70 per ton in 1907. Summer freighting on Fortymile Creek is done by poling boats. It is a difficult stream to navigate, and boat loads of material are frequently lost or long delayed by low water. The rates from Fortymile to the farthest locality, Chicken Creek, are about 25 cents per pound. Cattle are frequently driven overland on the wagon road from Dawson to Glacier, a distance of 60 miles, and thence to the various creeks on the Alaska side, where they are sold.

The road commission has surveyed a Government wagon road from Eagle to the Fortymile country and has already practically completed about 9 miles of it, from Eagle to American Creek. Work is also being done on a road to make the Seventymile country more accessible from Eagle. During the fall of 1907 a road was constructed by private means from the head of Canyon Creek to Walker Fork, in order to save the long haul up the Fortymile in the winter.

Work was commenced in 1907 on the survey of the international boundary southward from the Yukon. This work includes also the topographic mapping of a strip of country 2 miles wide each side of the boundary. The work is carried on by representatives of both governments. The results will be final and will set at rest all doubt on the part of the miners as to the position of the boundary.

GEOLOGIC SKETCH.

The rocks of the Fortymile quadrangle are composed of highly metamorphosed schists with interbedded limestones, all assigned provisionally to the pre-Ordovician; of less-metamorphosed rocks including Devonian phyllites, greenstones and limestones, and Carboniferous slates and limestones; of Tertiary clays, lignite, sandstone, and conglomerate; of bench and stream gravels probably of Pleistocene and Recent age; and of intrusive igneous rocks, some of which have been metamorphosed with the schists.

PRE-ORDOVICIAN ROCKS.

The schists include essentially thin-bedded, little-altered quartzites, quartzite schist, quartz-mica schist, garnetiferous mica schist, hornblende schist, and carbonaceous schist. All these may occur in close alternation with each other. Crystalline limestones are interbedded with them in layers from a few inches to a hundred feet or more in thickness. The structure is most complex. Dips and strikes present much variability. In places the rocks are nearly horizontal, but such horizontality is in some localities the result of complex folding. In general the rocks lie in a highly inclined attitude. Closely appressed folds are common, and these in places pitch at high angles, even becoming vertical. Furthermore, there has been motion that has resulted in shearing planes at angles with these highly pitching folds. Thinly bedded quartzite and mica schist have been thus transformed into rods of quartzite a foot or more in length, with lenticular cross sections an inch or more in diameter. In a weathered cross section of such beds the eyes of quartzite in a micaceous matrix present the appearance of a metamorphosed quartzite conglomerate. The structure is further complicated by the abundant occurrence of intrusives, some of which have become so closely incorporated with the schists that they are not easily recognizable as of different origin. In spite of the complexity of the structure, a general strike is discernible, and this is nearly east and west, with variations to the north and south of this direction.

These schists with their interbedded limestones form the bed rock throughout the southern half of the Fortymile quadrangle, with the exception of an area to the southwest occupied by the other formations referred to above and several considerable areas of the intrusives. These rocks are finely exposed in the valley of Fortymile Creek from a point a short distance above Franklin Creek to the international boundary and beyond into Canadian territory. In the northern part of the quadrangle they are present on Seventymile Creek at the falls and above to the limits of the quadrangle.

A narrow belt of them lies at the base of the ridge adjoining Mission Creek on the north. They form also Fortymile Dome. The approximate northern boundary, with the exception of the Mission Creek occurrence, which is probably isolated, extends from the north end of Glacier Mountain to the international boundary near the head of Liberty Fork. The age of these rocks is at present unknown. They are probably at least pre-Ordovician.

PALEOZOIC ROCKS.

Green and black phyllites, greenstones, and limestones, regarded as for the most part of Devonian age, are present in the northeastern part of the quadrangle in the drainage areas of American and Mission creeks. They form the bluff at Eagle and those above Eagle on the left bank of the Yukon, and are abundant along the river below Eagle, where they are associated with Carboniferous rocks. In the southwestern part of the quadrangle they occur on Fortymile Creek from the mouth of Denison Fork to a point about 2 miles above Franklin Creek. The drainage area of Chicken Creek is formed partly of these rocks. They occupy a belt in the area about the headwaters of King Solomon and Champion creeks. There is a small area also on Canyon Creek above the mouth of Mariner Creek. These rocks have in places been closely folded, but the degree of metamorphism is much less than that of the schists, fossil fragments, chiefly crinoid stems, being of common occurrence in the limestones.

TERTIARY DEPOSITS.

Tertiary clays and sandstones with some interbedded lignitic coal and massive conglomerates with interbedded shales have a wide distribution in the northern part of the quadrangle, in the valleys of Seventymile and Mission creeks, and small patches are found at the southwest in the valleys of Napoleon and Chicken creeks. These rocks have in places, notably on Seventymile Creek, been tilted to a vertical position, but are otherwise little altered.

ALLUVIAL DEPOSITS.

The alluvial deposits consist of the bench gravels, partly auriferous, such as occur on the high benches of Fortymile Creek, on the Lost Chicken bench, and on benches of intermediate height, and the deposits of the present streams. The bench gravels have been found to a height of about 300 feet above the streams and have a thickness in places of about 50 feet. The stream gravels are in part auriferous and are in the main sufficiently shallow to be worked by open cuts. Chicken Creek is the only locality where the depth is considerable, reaching, in some of the ground that is being drifted, about 45 feet.

The alluvial deposits have been derived from the bed rock in the drainage areas in which they are found.

The material on the bars of Fortymile Creek has been derived from widely distant sources and a large variety of bed rock. The stream meanders in its course, leaving bars of this material deposited on the irregular planated surface of the schistose bed rock. Many of these deposits were rich in gold and the cleaned-out crevices of the bed rock on nearly every bar along the creek attest the thoroughness of the work done in the early days. On many of the bars the bed rock slopes very gradually upward until it is concealed by the overlying deposits; on other bars the slope is more abrupt, leaving but a narrow margin for work. All the most workable bars have inherited names, and at the present time many of those best known are being prospected with reference to dredges and values have been found in some of them averaging a cent to the pan. Some of the bars are backed by flats up to 1,000 feet or more in width, and the gravels of these flats are also being investigated.

IGNEOUS ROCKS.

The igneous rocks of the Fortymile quadrangle are predominantly intrusives, partly fresh and partly altered into gneisses. Altered diabasic and basaltic flows, with associated tuffs, are present in the areas occupied by the Devonian rocks.

The most common types of intrusives are granitic and dioritic rocks, but more basic rocks are also present. A large area in the northwestern part of the quadrangle, topographically emphasized by Glacier Mountain, is formed of quartz diorite. Numerous dikes and sills of the same rock and more basic varieties derived from the same magma penetrate the surrounding schists over a distance of several miles from the main mass. Another large area of similar rocks enters the southwest corner of the quadrangle, forming much of the bed rock in the Chicken Creek valley. Dikes and sills of biotite granite, hornblende granite, and diorite are abundant in the schists throughout the Fortymile country. A very common intrusive in this country is composed essentially of quartz and feldspar, and this rock with the disappearance of the feldspar forms quartz veins. A part of the quartz veins of the Fortymile region are thus of magmatic origin. This quartz-feldspar material has been intruded partly in the igneous rocks and partly as both dikes and sills in the surrounding schists. When the intrusions took place the intruded rocks were evidently at such a temperature as to allow the entrance and coarse crystallization of very thin sheets of the igneous material in both the crosscutting and concordant relation with the schists, and so extensively was this process in operation at some localities that a large proportion of the rock is composed of granitic material.

These magmatized schists have later been folded, and the acidic dikes have been crumpled and even torn apart into lenticular fragments. At a far subsequent period the granites and schists have been cut by a few dikes of basalt, the material of which is still practically unaltered.

ORIGIN OF GOLD.

At a few localities in the Fortymile region gold has been found in the bed rock. In the intrusive mass of quartz diorite that occurs in the southwestern part of the area, at a locality on Mosquito Fork about 2½ miles west of Chicken Creek, there is a zone about 6 feet wide that is partly brecciated and has been impregnated with quartz and pyrite. The weathered material pans fine flour gold and an average of two assays of surface material collected in 1903 gave a gold content of $9.70 per ton. Assays giving much higher value have been reported. Near the head of Chicken Creek black and greenish slates, with some limestone, occur in close relation with intrusive quartz diorite porphyry. These slates contain thin quartz and calcite veins. Iron pyrite is common in the quartz veins. In some of the thinner calcite veins there is a considerable proportion of gold, occurring as small lumpy masses and as thin plates along the cleavage planes of the calcite. The placers of Chicken Creek have probably derived at least a considerable part of their gold from such small stringers. Silver sulphide has been found associated with the gold in the placers below this locality. It is believed that in these two places the occurrence of gold is due to the after-effects of the igneous intrusives.

Gold has also been found in place in the ridge south of Kalamazoo Creek, a tributary of Canyon Creek. At this locality there is a conspicuous outcrop of brecciated quartzite and vein quartz that is in places very rusty from the large amount of iron content. Specimens have been obtained showing free gold in the rock. It is not known, however, whether gold is uniformly distributed through the rock or whether it is only of local occurrence. Placer gold is found in creeks draining this area and it is believed by the miners to have been derived from this locality.

In the Seventymile area gold has been found in place in a mineralized zone in serpentine. At this locality there are many intersecting small quartz veins containing considerable iron pyrites. Gold is reported in the weathered vein material, and the attempt has been made to save it by means of an arrastre.

The alluvial deposits of the streams, where mining is in progress, have been derived from the bed rock of the valleys in which they occur, and there has been in this area no interference by glaciation with the orderly deposition of material by stream action. The bed rock in some of these valleys is almost exclusively composed of schists of sedimentary origin containing many small quartz veins. Nuggets are frequently found with considerable quartz attached, and it is probable that they have been derived from such quartz veins. Small veins of barite also occur in the schists, and small rounded pebbles of this material accompany much of the gold, along with garnets, rutile, and black sand. Hematite and limonite pebbles are also common associates of the gold. Native lead has been found on Franklin Creek, and in the Seventymile area cinnabar pebbles are occasionally found.

MINING DEVELOPMENT.

Mining by the usual methods in the Fortymile quadrangle during the summer of 1907, partly on account of the prolonged dry weather, was not being carried on very extensively. Many of the bars of Fortymile Creek have been worked for years, and even during 1907 a few miners were found still making wages in the old way with the rocker. The prevailing low stage of water was especially favorable for this kind of work. Operations on Chicken Creek were practically at a standstill, but the field had been somewhat enlarged by the work on Ingle Creek and at the head of Chicken Creek. Sluicing was being done at the mouth of Napoleon Creek, and a few men were working intermittently on Franklin Creek. Ground was being tested at several localities along Fortymile Creek itself, and at Moose Creek a combined ditch and flume was being constructed to bring water about 3 miles to one of the Fortymile bars. Wade Creek was not visited, but the reports indicated more favorable conditions for work.

The greatest change of methods in the Fortymile region has been in the introduction of dredges. Four steam-power dredges were in process of installation or in operation during the season of 1907—one on Walker Fork, just above the mouth of Twelvemile Creek, and three on Fortymile Creek (about 2 miles below the mouth of Franklin Creek, at the international boundary, and about 4 miles above the mouth in Canadian territory). Plans were also under way for installing a dredge on the upper part of Walker Fork during the winter of 1907–8.

The ground to be worked by the dredge on Walker Fork near Twelvemile Creek was reported to range from 6 to 14 feet in thickness, with an average of about 9 feet. The muck was from 1½ to 4 feet thick. The bed rock is schist, with intrusive granite. The gold is said to be mostly on bed rock or within it to a depth of a few inches. The stream flat at this point is several hundred feet wide and the alluvial deposits are frozen. Steam points were in use to thaw ahead of the dredge. The dredge is a bucket open-connected dredge, with buckets having a capacity of 5 cubic feet. It was reported to be capable of working about 3 acres a month. The frozen character of the ground, however, made it impossible to use the dredge to advantage. It has been found necessary to prepare ground by stripping at least a year in advance in order to give it the best opportunity possible for thawing and thus save to a great extent the extra expense of thawing by steam points.

The dredge on Fortymile Creek at the international boundary is similar in character, with 2½-foot buckets and a capacity of about 1,500 cubic yards in twenty-four hours. The dredge was working on a bar where the average depth to bed rock is about 8 feet. While bowlders were somewhat troublesome, the ground was for the most part unfrozen.

The dredge on the Canadian side of the boundary has a capacity of 3,000 cubic yards in twenty-four hours. It has 5-foot buckets and can work ground to a depth of 35 feet. This dredge also was working on a bar of Fortymile Creek where the ground was not frozen and the bed rock soft.

The machine in process of installation on Pump Bar, below the mouth of Franklin Creek, is a dipper dredge. The machinery was being mounted on a scow 42 by 80 feet, built of native spruce lumber. The dipper has a capacity of 2½ cubic yards, and the machine was expected to handle about 1,000 cubic yards in ten hours. The ground to be worked was all unfrozen and averaged about 6 feet in thickness.

Some of the factors to be considered in the installation of dredges, aside from the great question of the values in the ground, which are sometimes barely investigated, are as follows: Remoteness of a region and absence of communication, entailing costly delays in installation, repairs, and procurement of supplies to keep a dredge in continuous operation; length of working season; water and fuel supplies; dimensions and character of alluvial deposits, with special reference to frost and bowlders; vertical and horizontal distribution of the gold in the deposits and the character of the gold; evenness or unevenness of the bed-rock surface, ridges of bed rock in some places interfering with the ability of the dredge to work all portions of the ground; hardness of bed rock; its receptivity for gold and adaptability for dredging; and, finally, the selection of a dredge best adapted to the conditions presented by the ground under consideration.

The Fortymile region comes well under the definition of remoteness. It is more unfortunate in this respect than the other mining regions in the Yukon-Tanana country. The length of the working season is limited to about four months. Most of the valleys are sufficiently timbered with spruce to have furnished up to the present time abundant fuel. The ground selected for dredging is in the valleys of the smaller tributaries of Fortymile Creek or along the bars of the creek itself. The deposits are such as have been worked by open cuts, and most of them are much under the maximum depths workable by the dredges already on the ground, 15 to 35 feet; some are even shallower than desirable. These deposits are of local origin, having been derived from the bed rock within the valleys, and are composed of gravels overlain by muck. They are, for the most part, frozen throughout the year. The gravels are composed of subangular or rounded fragments, up to a foot or more in diameter, and a large proportion of fine material, partly comminuted fragments of the same character as the coarser materials and partly products of decomposition. The proportion of bowlders is generally small, but at some localities it is so large as to become a troublesome factor. If it were not for the frozen character of the gravels, the conditions for dredging would be about as favorable as at some localities in the States. The overlying muck is removed by ground sluicing, and this process of stripping is one that requires a wide experience in the utilization of water to procure the best results. Although in some places the gold is found distributed through the lower part of the gravels, it is mostly on or within the bed rock. On some creeks there is a large proportion of nuggety gold. The greatest part of it, however, occurs as small flat pieces, and there is some very fine gold.

The bed rock in the Fortymile region is predominantly schist, with interbedded crystalline limestone and intrusive granitic rocks, either parallel to the structure or cutting it. Beds of more or less blocky material resistant to weathering are separated by softer material, and this characteristic gives rise in some places to an uneven bed-rock surface, the higher places of which may act as a hindrance to dredging. This emphasizes the need of a careful preliminary survey of the deposits and the underlying rock floor. Furthermore, the gold has a tendency to sink to a depth of several feet in the crevices and joint planes of the blocky bed rock.

Several plans have been under consideration for the utilization of the water supply in the Fortymile region, and during the summer of 1907 a dam was being constructed on Mosquito Fork near Kechumstuk for the purpose of bringing water by a ditch to the Chicken Creek area.

In the vicinity of Eagle mining operations were confined mainly to preparatory and assessment work. A dam with automatic gate was being constructed on American Creek. The new Government road is already proving of advantage to this locality. Work in the Seventymile area is also being helped by the construction of a road over the divide from Excelsior to Seventymile Creek.

PRODUCTION.

The largest part of the production of the Fortymile district is taken out of Alaska by way of Fortymile Creek. The following table has been prepared from records furnished to the Survey by the office of the United States customs service at the subport of Fortymile, Alaska. It shows the distribution and amount of production for the years 1904 to 1907, inclusive. Quantities are expressed in fine ounces, the value of the fine ounce being approximately $20.67, whereas that of the commercial dust of the Fortymile district averages about $17 to the ounce.

Production of gold in Fortymile region, 1904–1907.

Creek.	1904.		1905.		1906.		1907.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
	Fine ounces.		*Fine ounces.*		*Fine ounces.*		*Fine ounces.*	
Chicken, Lost Chicken, Myers Fork, Stonehouse, and Ingle	6,819.74	$140,964	5,368.11	$110,959	4,269.32	$88,247	2,377.74	$49,147
Franklin	494.29	10,217	581.47	12,019	783.79	16,201	100.34	2,074
Wade	5,233.24	108,171	4,521.00	93,449	3,094.87	63,971	3,381.90	69,904
Walker Fork, Poker, and Davis	1,222.11	25,262	1,124.28	23,239	1,184.32	24,480	484.42	10,013
Squaw, Camp, Woods, and Canyon	156.27	3,230	103.62	2,142	63.32	1,309	123.36	2,550
Napoleon, Montana, Buckstein, Dome, Eagle, and Twin	51.00	1,054	46.06	952	13.11	272	11.51	238
Fortymile bars and commercial dust	886.60	18,326	637.40	18,175	437.54	9,044	266.47	5,508
	14,863.25	307,224	12,381.94	255,935	9,846.27	203,524	6,745.74	139,434

These statistics, together with incomplete data of production for 1907 from creeks in the vicinity of Eagle—about 400 fine ounces, or $8,245—indicate a total production for the year 1907 in the Fortymile district of approximately $150,000.

WATER SUPPLY OF THE FAIRBANKS DISTRICT. 1907.

By C. C. Covert.

INTRODUCTION.

During the season of 1907 the United States Geological Survey extended to the Fairbanks district the stream-gaging work started in the Nome region in 1906. The investigations were for the purpose of determining both the total flow and the distribution of flow during the open season, and of collecting data regarding the general conditions affecting the water supply and its development.

The success of any project for water-supply development is measured largely by the completeness of the information on which the engineer designs his work in accordance with the maximum efficiency of the available flow, and this efficiency can be determined with greater accuracy by the aid of long and continued records. It is for the purpose of procuring such records that the Survey has undertaken the study of stream flow in this district.

The field work in the Fairbanks district was carried on from June 20 to September 15. Owing to the lack of adequate funds the work was largely that of reconnaissance. However, the keeping of systematic records on some of the more important streams was made possible through the hearty cooperation of people interested. Among the many who rendered valuable assistance in procuring the data given in the accompanying tables, acknowledgment is due to Mr. John Zug, superintendent of the good roads commission; Mr. A. D. Gassaway, general manager of the Chatanika Ditch Company; Mr. Falcon Joslin, president of the Tanana Mines Railroad Company; Mr. Herman Wobber, Fairbanks Creek; Mr. C. D. Hutchinson, electrical engineer, Tanana Electric Company; and Mr. Martin Harris, Chena.

After making a careful study of the general topographic conditions of the mining district and its surrounding country, it was decided to establish a few regular stations at the most convenient points in the larger drainage areas, and to study the daily run-off, during the open season, from records thus obtained. This plan afforded greater opportunity for procuring comparative data than would that of covering a larger territory in a less definite way. In this country without storage daily records are an important factor, and such records could not have been obtained over an extended area. Outside of the producing creeks the country is practically a wilderness, and it is almost impossible to get observations, other than those made on the occasional visits of the engineer. No daily or even weekly records could have been assured, and the results obtained from the occasional measurements would have furnished no comprehensive idea as to what the daily run-off of the streams really was throughout the open season.

MEASUREMENTS.

Discharge measurements were made at 45 different stations as listed below. The detailed results are published in Water-Supply Paper No. 218, from which the accompanying summaries are taken.

Gaging stations in Fairbanks district.

1. Little Chena River about 2 miles above Elliott Creek.
2. Elliott Creek above mouth of Sorrels Creek.
3. Sorrels Creek above mouth.
4. Fish Creek above Fairbanks Creek.
5. Bear Creek near mouth of Tecumseh Creek.
6. Fairbanks Creek.
7. Miller Creek near mouth.
8. Miller Creek below Helm Creek.
9. Miller Creek above Helm Creek.
10. Charity Creek 1 mile above mouth of Hope Creek.
11. Hope Creek near mouth of Zephyr Creek.
12. Faith Creek at weir near mouth.
13. McManus Creek above Montana Creek.
14. McManus Creek below Montana Creek.
15. McManus Creek 1 mile below Idaho Creek.
16. McManus Creek 500 feet above mouth of Smith Creek.
17. McManus Creek below mouth of Smith Creek.
18. McManus Creek at mouth.
19. Smith Creek below mouth of Pool Creek.
20. Smith Creek above mouth of Pool Creek.
21. Pool Creek above mouth.
22. McManus Creek at weir near mouth.
23. Chatanika River below Faith and McManus creeks.
24. Boston Creek at elevation 800 feet.
25. McKay Creek at elevation 800 feet.
26. Belle Creek at elevation 800 feet.
27. Crooked Creek near mouth.
28. Kokomo Creek near mouth.
29. Poker Creek near mouth.
30. Poker Creek near elevation 800 feet.
31. Little Poker Creek above mouth.
32. Caribou Creek above mouth of Little Poker Creek.
33. Chatanika River below mouth of Poker Creek.
34. Cleary Creek near Cleary.
35. Little Eldorado Creek above trail to Dome Creek.
36. Dome Creek near Dome.

37. Goldstream Creek between claims 6 and 7 " B."
38. Fox Creek near elevation 900 feet.
39. Beaver Creek above mouth of East Branch.
40. East Branch of Beaver Creek above mouth.
41. Nome Creek 1 mile above mouth.
42. Bryan Creek at elevation 1,800 feet.
43. Trail Creek about 4 miles above mouth.
44. Brigham Creek 1 mile above mouth.
45. Fossil Creek near mouth.

Tables 1 and 2 show the monthly discharge of the streams where the daily flow could be computed. Table 3 gives the minimum daily flow of these streams. Table 4 gives the mean weekly supply. Table 5 is a list of miscellaneous discharge measurements made on different streams. All these results are given in second-feet, which can be reduced to miner's inches of 1.5 cubic feet by multiplying by 40.

TABLE 1.—*Monthly discharge of streams in Little Chena River basin, 1907.*

LITTLE CHENA RIVER ABOVE ELLIOTT CREEK.

[Drainage area, 79 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
July 22-31	80	42	49.3	0.625	0.23
August	157	53	85.4	1.08	1.24
September 1-10	95	66	86.2	1.09	.40
51 days	157	42	78.4	.993	1.87

ELLIOTT CREEK NEAR MOUTH OF SORRELS CREEK.

[Drainage area, 13.8 square miles.]

July 22-31	9	2.5	5.9	0.430	0.16
August	23	5.8	11	.797	.92
September 1-10	12.3	9	10	.724	.27
51 days	23	2.5	9.82	.711	1.35

SORRELS CREEK NEAR MOUTH.

[Drainage area, 21 square miles.]

July 22-31	14.7	6.0	10.5	0.500	0.19
August	32.1	10.3	18.2	.867	1.00
September 1-10	19	14.7	16	.762	.28
51 days	32.1	6.0	16.3	.777	1.47

FISH CREEK ABOVE FAIRBANKS CREEK.

[Drainage area, 39 square miles.]

July 22-31	24	18	22.5	0.577	0.21
August	155	24	36.8	.944	1.09
September 1-10	35	24	26.6	.682	.25
51 days	155	18	32.0	.820	1.55

TABLE 2.—*Monthly discharge of streams in Chatanika River basin, 1907.*

FAITH CREEK NEAR MOUTH.

[Drainage area, 51 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
June 20-30	45.9	34.4	40.5	0.795	0.32
July	62.5	19.2	29.2	.572	.66
August	87.4	26.9	47.5	.932	1.07
73 days	87.4	19.2	38.5	.755	2.05

McMANUS CREEK NEAR MOUTH.

[Drainage area, 80 square miles.]

June 20-30	34.8	21.7	28.5	0.356	0.15
July	40	15.0	21.4	.268	.31
August	114	32.2	66.4	.830	.90
73 days	114	15.0	41.5	.510	1.42

CHATANIKA RIVER NEAR FAITH CREEK.

[Drainage area, 132 square miles.]

July 17-31	90	54	67	0.508	0.29
August	183	73	117	.887	1.02
September	1,770	110	297	2.18	2.43
76 days	1,770	54	178	1.31	3.74

KOKOMO CREEK NEAR MOUTH.

[Drainage area, 26 square miles.]

July 9-31	25.8	7.9	14.2	0.546	0.47
August 1-14	112	22.7	41.6	1.60	.83
37 days	112	7.9	23.8	.916	1.30

CHATANIKA RIVER BELOW POKER CREEK.

[Drainage area, 456 square miles.]

June 20-30	250	192	228	0.500	0.20
July	283	167	211	.463	.53
August	1,160	216	428	.939	1.08
September	3,160	300	954	2.09	2.33
October 1-14	860	232	506	1.11	.47
117 days	3,160	167	496	1.08	4.61

GOLDSTREAM CREEK NEAR CLAIM 6 BELOW.

[Drainage area, 28.6 square miles.]

June 20-30	30.2	4.9	13.4	0.469	0.19
July	34.4	2.2	13.1	.458	.53
August	32.2	10.8	20	.699	.81
September	41	15.4	24	.839	.94
October 1-7	24.4	17.1	20.7	.724	.19
110 days	41	2.2	18.5	.649	2.66

TABLE 3.—*Minimum daily flow of streams in Fairbanks district, 1907.*

	Elevation.	Date.	Minimum flow.	Drainage area.	Minimum run-off per square mile.	Duration of record.
	Feet.		*Sec.-feet.*	*Sq. miles.*	*Sec.-foot.*	
Little Chena River above Elliott Creek.	800	July 22-25, 29-31.	42	79	0.53	July 22-Sept. 10.
Elliott Creek above Sorrels	800	July 31	2.5	13.8	.18	Do.
Sorrels Creek above mouth	800	do	6	21	.28	Do.
Fish Creek above Fairbanks Creek.	925	July 30-31	18	39	.46	Do.
Faith Creek at mouth	1,400	July 10	19.2	51	.38	June 20.
McManus Creek at mouth	1,400	July 10-12	15	80	.19	Do.
Chatanika River below Faith Creek.	1,350	July 31	54	132	.41	July 17-Sept. 30.
Kokomo Creek near mouth	750	July 23, 30-31	7.9	26	.30	July 9-Aug. 14.
Chatanika River below Poker Creek.	700	July 4-7, 10	167	456	.36	June 20-Oct. 14.

TABLE 4.—*Mean weekly water supply, in second-feet, from Little Chena and Chatanika River basins, 1907.*

Date.	Available for use by diversion at elevation 1,350 feet.	Available for use by pumping at elevation 700 feet.	Available for use by diversion at elevation 800 to 900 feet.				Total, Little Chena drainage area.
	Chatanika River near Faith Creek.	Chatanika River below mouth of Poker Creek.	Little Chena River above Elliott Creek.	Elliott Creek above Sorrels Creek.	Sorrels Creek above mouth.	Fish Creek above Fairbanks Creek.	
June 17-23	86						
June 24-30	64	216					
July 1-7	44	178					
July 8-14	36	190					
July 15-21	64	250					
July 22-28	70	224	52	7	12	24	95
July 29-August 4	80	540	80	12	18	55	165
August 5-11	128	516	110	12	24	42	188
August 12-18	82	313	73	10	16	26	125
August 19-25	104	260	56	6	10	24	96
August 26-September 1	169	413	90	11	18	26	145
September 2-8	120	324	82	9	15	26	132
September 9-15	513	1,360					
September 16-22	376	1,480					
September 23-29	216	737					
September 30-October 6		655					
October 7-13		415					
Mean	143	504	78	10	16	32	136
Maximum	513	1,480	110	12	24	55	188
Minimum	36	190	52	6	10	24	95

TABLE 5.—*Miscellaneous measurements in Fairbanks district, 1907.*

LITTLE CHENA RIVER DRAINAGE BASIN.

Date.	Stream.	Locality.	Discharge.
			Sec.-ft.
July 20	Bear Creek	Near Tecumseh	8.4
August 22	do	do	7.0
June 24	Fairbanks Creek	Elevation 1,300 feet	1.4
Do	do	Elevation 1,250 feet	2.2
July 5	do	Elevation 1,375 feet	.72
July 20	do	Elevation 1,400 feet	1.3
July 6	Miller Creek	Near mouth	7.00
July 24	do	do	7.6
August 20	do	do	8.0
August 6	do	Below mouth of Heim Creek	8.0
August 7	do	do	8.0
Do	do	Above mouth of Heim Creek	4.9

CHATANIKA RIVER DRAINAGE BASIN.

July 11	Hope Creek	Near mouth of Zephyr Creek	7.7
Do	Charity Creek	1 mile above mouth of Hope Creek	5.7
July 10	McManus Creek	At mouth	15.6
Do	do	do	16.4
July 12	do	Above Smith Creek	10.2
Do	Smith Creek	Near mouth	7.8
Do	McManus Creek	do	15.6
July 13	do	¾ mile above Montana Creek	1.8
Do	do	Below Montana Creek	3.8
Do	do	1½ miles below Idaho Creek	6.5
Do	do	½ mile above mouth	[a] 21.4
July 14	do	500 feet above Smith Creek	12.4
Do	Smith Creek	Near mouth	8.7
Do	do	Above Pool Creek	5.4
Do	Pool Creek	Above mouth	2.4
Do	McManus Creek	do	[a] 19.4
August 15	Boston Creek	Elevation 800 feet	3.9
Do	McKay Creek	do	3.7
Do	Belle Creek	do	10.0
Do	Crooked Creek	Near mouth	6.3
July 27	Poker Creek	½ mile above mouth	22.3
July 30	do	do	22.6
August 9	do	do	36.6
August 10	do	do	37.8
Do	Caribou Creek	Above Little Poker Creek	10.4
Do	Little Poker Creek	Near mouth	3.9
Do	Poker Creek	1 mile above Caribou Creek	21.1
July 4	Cleary Creek	Near Cleary	2.9
June 26	Little Eldorado Creek	Above trail to Dome Creek	.45
June 27	Dome Creek	Near Dome	.84
July 6	Fox Creek	Elevation 900 feet	2.0

BEAVER CREEK DRAINAGE BASIN.

August 27	Trail Creek	Approximate elevation, 1,700 feet	39.9
Do	Brigham Creek	Approximate elevation, 1,500 feet	16
August 28	Fossil Creek	Approximate elevation, 1,300 feet	19.2
August 29	Bryan Creek	Approximate elevation, 1,800 feet	75.3
August 30	Beaver Creek above East Branch.	do	267
Do	East Branch of Beaver Creek above mouth.	do	124
Do	Nome Creek near mouth.	Approximate elevation, 1,700 feet	135

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[a] Measurement approximate.

RAINFALL.

In connection with these investigations the following rainfall stations were established:

Summit Road-house near Pedro Summit, elevation 2,310 feet.
Cleary City, elevation 1,000 feet.
Chatanika River near mouth of Poker Creek, elevation 730 feet.
Chatanika River near mouth of Faith Creek, elevation 1,400 feet.

The results of the observations taken at these stations, together with records kept at Fairbanks in 1906 and 1907, are as follows:

Monthly precipitation in inches at stations in Fairbanks district, 1906–7.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1906.													
Fairbanks [a]	1.75	0.37	0.33	0.10	0.36	1.05	2.82	1.50	0.25	0.30	0.65	1.15	10.63
	17.5	3.7	3.3	1.0						1.6	6.5	11.5	45.1
1907.													
Fairbanks [a]	3.3	.86	2.42	.03	.35	1.47	1.51	1.81	3.58	2.44			
	33.0	8.6	24.2	.30						24.4			
Summit Road-house							2.71	3.27					
Cleary						.84	2.55	2.88	3.82				
Poker Creek [a]								1.40	3.70	1.70	.25		
										24.0	3.3		
Faith Creek							1.87	3.00	2.97				

[a] Rainfall or melted snow is given in the first line; snowfall in the second line.

HYDRAULIC DEVELOPMENTS.

In the Fairbanks district little work has been done as yet toward constructing ditch lines from larger drainage areas for additional water supply. Mining has been carried on entirely by means of the meager supply from individual creeks. The camp is rapidly approaching a stage of development that demands a greater water supply than these creeks can furnish.

In general, the relation of the mining camps to the surrounding country is not favorable to an outside water supply by gravity. The topography of the country is such that ditch lines from the larger drainage areas are not altogether practical. The camp lies in three drainage basins, or valleys, separated by high dividing ridges, and in order to supply the producing creeks in one valley with the water by ditch line from another the ditch must have a high elevation, which throws its intake so far into the headwaters that there is only a small drainage area from which to draw the supply and consequently but little water. The records kept during the season of 1907 prove conclusively that had the high-line ditch which the Chatanika Ditch Company proposed to build from the upper Chatanika basin to the mining camp been built, instead of a daily supply of 125 second-feet, as was estimated, it would have had less than half that amount during the greater part of the open season.

However, investigations are under way which may overcome these difficulties. It is proposed to construct, from the mouth of Faith Creek to the mining camp, a ditch which will supply water to the producing creeks directly tributary to Chatanika River. A project is also under way to develop electric power for transmission to the mining camp by using the waters of Little Chena River. This project will also supply water to Smallwood, Nugget, and other creeks in the vicinity.

The development of water power for electric transmission in the Fairbanks district seems worthy of consideration. This method of utilizing the water supply would dispense with many miles of ditch construction and would not only furnish the camp with water, but also with power for running the hoist, elevating the tailings, pumping water from the mines, lighting the underground work, pumping water to the sluice box, and, in some localities, running the dredge.

INVESTIGATIONS OF THE MINERAL DEPOSITS OF SEWARD PENINSULA.[a]

By PHILIP S. SMITH.

INTRODUCTION.

It is intended in this paper to summarize the results of the geologic investigations which have been carried on in Seward Peninsula since the close of 1906. As an account of the earlier developments has been given in former progress reports,[b] a repetition of the facts there set forth is unnecessary and undesirable.

PRODUCTION.

In Seward Peninsula the past year has been marked by increased activity in prospecting for both placers and lodes, but so far no strikes of rich bonanzas such as characterized the winter of 1905–6 have been made. An estimate, compiled from various sources, of the amount of gold produced by the entire peninsula for the year 1907 shows the value of the output to be about $6,750,000. The production of gold in Seward Peninsula from 1897, the first year in which any notable amount of gold was won, down to the present time is shown in fig. 3. It will be noticed that in 1907 the production showed a decrease of about $750,000 over that of the preceding year. The high total in 1906 was due to the discovery and development of the phenomenally rich placers of the ancient beach about 3 miles north of Nome. Although extensions of this beach have been uncovered during the last year, nowhere else has the beach proved as rich as in the portion first discovered, between Snake and Nome rivers. But, as the mining of placers goes on with much rapidity, the explored ground on this portion of the beach has been more or less exhausted. As an instance of this may be cited the richest of all the third-beach mines, which early in the summer finished hoisting the last of its gravel. Just as the modern beach was soon exhausted, so this more ancient one has yielded up its treasure for nearly 3 or 4 miles of its length. With the exhaustion of the present beach new placer fields of even greater value were discovered, but no such good fortune has followed the yearly depletion of the store of gold in the ancient beach. It is the normal history of a placer camp to undergo great fluctuations in production, so that the falling off in 1907 does not, in all probability, mark the decline of the Seward Peninsula camps.

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[a] In collecting data for many portions of this report the writer was assisted by G. I. Finlay and Frank J. Katz during the field season of 1907.

[b] Brooks, A. H., Placer mining in Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 19–24. Moffit, F. H., Gold mining in Seward Peninsula: Bull. No. 284, 1906, pp. 132–141; The Nome region: Bull. No. 314, 1907, pp. 126–144. Smith, P. S., Gold fields of Solomon and Niukluk River basins: Bull. No. 314, 1907, pp. 146–156; Geology and mineral resources of Iron Creek: Bull. No. 314, 1907, pp. 157–163. Brooks, A. H., The Kougarok region: Bull. No. 314, 1907, pp. 164–179.

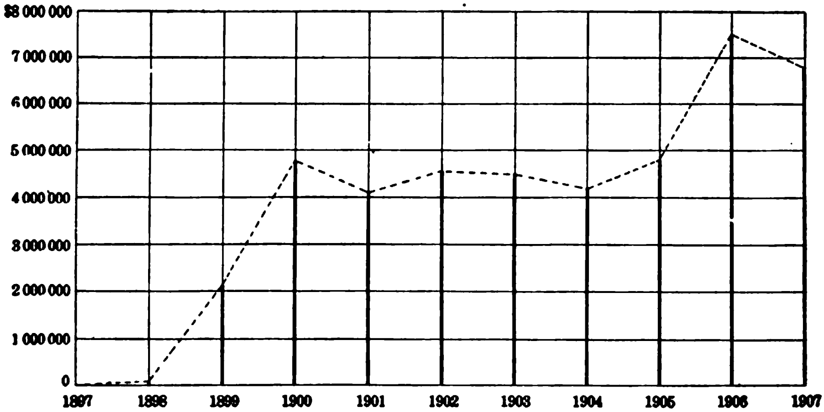

FIG. 3.—Gold production of Seward Peninsula, 1897–1907.

Although the decrease in gold is attributable mainly to the exhaustion of some of the rich bonanzas of the preceding year, there are several minor factors which may have also had some effect in reducing the output of the district. One of these minor causes was the labor trouble, which culminated in a strike during a portion of the winter of 1906–7. Previously it had been the custom to make winter wages one-half the summer rate, which is $5 a day and board. This scale was adopted because in the winter the country was oversupplied with labor. Such a condition is practically inevitable because in the winter all the shallow workings, which are active during the summer, of necessity are closed, only drift mines being operated. Thus the number of men who can be employed in the winter is only a small fraction of the number needed in summer. The surplus workmen must seek other regions, go prospecting on their own account, or accept the wages that are offered. The first two choices are not open to all, for they require a certain amount of capital and therefore many are compelled to accept the third. Under such conditions those needing labor can dictate the terms of employment.

During the winter of 1906–7, however, the men tried to force the adoption of a higher scale of wages, amounting to a raise of about 50 cents a day on the old winter rate, and, failing to have the demand recognized, quit work. This strike lasted in an acute stage for about a month. During this time the mine operators adopted one of two policies. The larger operators, anxious not to lose a day of valuable time from hoisting pay gravels, acceded to a raise in wages. Many of the smaller operators, who were either finishing up the last of their hoisting or whose lack of funds prevented their granting the higher scale, closed down. Personal communication with many of the smaller operators, however, led to the conclusion that the closing of their mines did not materially alter their production, but simply postponed their hoisting to a little later in the season and made them rush work a little more vigorously during the shorter time in which they had to operate. It is therefore the opinion of the writer that although the effect of the strike was depressing on the total production, the result was not so serious as many promoters would have the public believe.

Although it is conceded that the strike may have somewhat decreased the production of gold in 1907, it is believed that the effect may not have been entirely insalutary. This statement does not rest on the probable solution of the labor problem involved. The most beneficial result of the strike was that when several of the mines were closed and the laborers had to shift for themselves, many of the more energetic turned their attention to prospecting. Such prospecting must inevitably result in much good, for the future of Seward Peninsula depends not so much on the complete economical working out of the known deposits as on the systematic search for new fields and the extension of the known placer grounds.

Prospecting at the present time is much hampered in Seward Peninsula by the fact that nearly every available bit of ground has been staked. Even though the person desiring to locate knows that the annual assessment work has not been done, he is confident, from the bitter experience of many others, that successful location of pay gravel on the ground in question will inevitably lead to legal complications. For this reason prospecting by individuals is discouraged. The new law laying the burden of proof of assessment work on the holder if he does not record his work is variously viewed by different prospectors. There is, however, a feeling that a method of proving assessment work even more radical than by the word of witnesses is required to meet the best interests of prospectors.

CRITICISM OF POPULAR THEORIES.

Certain facts have been pointed out in previous reports which if heeded by prospectors would cause them to conduct their search with more promise of success than the hit-or-miss style so often adopted. Nevertheless there are numerous popular misconceptions which seem to have taken root in the minds of some inexperienced miners, and which are bound to have a retarding effect on the development of the district. The three most pronounced of these misconceptions are the theory that a second bed rock may be found below the first, the theory that the ledges are not wholly in place, and the theory that there is a uniformity of elevation of possible ancient beach lines in areas outside of the now partly explored Nome tundra.

ABSENCE OF MORE THAN ONE BED ROCK.

In regard to the first fallacy, it is necessary to understand clearly what is meant by the term bed rock. According to the loose usage prevalent among prospectors, bed rock is any layer of clay, sand, or other material on which gold is found. Such, however, is not the accepted scientific meaning of the term, by which bed rock is defined as the consolidated hard rock,[a] such, for instance, as the schist or limestone of Seward Peninsula. If used with this distinction it may be stated that there is no chance of finding a second bed rock below the first. It is evident, therefore, that drilling or exploration for placers beneath the hard schist bed rock is not advisable.

In making this statement the writer is well aware that certain peculiarities have been encountered which at first sight might suggest to the inexperienced that unconsolidated gravels do occur beneath the schist. One such peculiarity is afforded by the Golden Gate well at Nome, in which schist nearly 100 feet thick was encountered at a depth of 40 feet, and below it quicksand was struck. Various explanations have been suggested to account for this occurrence. Somewhat similar conditions were observed at the Daisy mine, near Nome. At this place a hole (A, fig. 4) was sunk 22 feet to what was supposed to be bed rock of schist, into which the hole penetrated for 8 feet. The hole was then abandoned and a new one started at B. In this hole pay was struck, and drifting on it traced the pay streak over in the direction of A. When the claim was carefully surveyed it was found that the drift from B was 67 feet below the bottom of hole A and directly under it. The explanation of the section is suggested in fig. 4 by dotted lines. It is believed that the schist of hole A, which was thought to be bed rock, was merely a piece of slide and that the real bed rock was the schist encountered in hole B underlying the pay. The conclusion that the schist encountered in the first hole is not in place is unavoidable, for there is no known or conceivable process in nature which could produce a schist from gravels and not profoundly modify the underlying gravels as well. Schists are formed by one of two main processes, which may be summarized briefly as contact metamorphism and dynamic metamorphism. The first method of schist formation is due to contact with igneous rocks; but the blocks of schist found in the midst of gravels could not have been produced in this manner, for, as is well known to every miner, there are no igneous rocks cutting the gravels near the places where the schist blocks occur. In the production of schists by dynamic action the mass of original material is moved and deformed. This process may take place deep under the surface as a result of the increased temperature produced by deep burial. But if such is the case the underlying gravels must have been subjected to just as much metamorphism as the layer which is supposed to have been changed into a schist. Another way in which schists may be formed by dynamic metamorphism is by the folding and deformation of rocks when subjected to mountain-building pressures. Such a process could not have affected this region after the underlying gravels were deposited, for the planes of original sedimentation, which are clearly visible in the gravels, have not been much disturbed.

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[a] According to the Standard Dictionary, bed rock is "the solid rock underlying the looser material of the earth's surface."

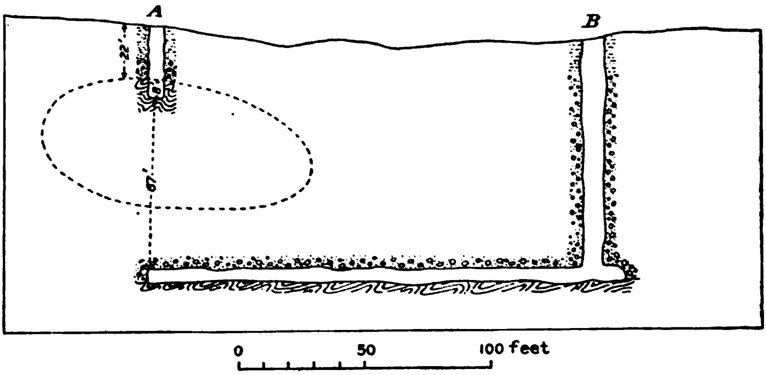

FIG. 4.—Diagrammatic cross section at the Daisy mine, near Nome.

It seems, therefore, that there is no reasonable way in which schist may be formed in the midst of a gravel deposit. It seems also evident that where the so-called "bed rock" is simply a stratum of clay or sand on which values may or may not be found, there is indisputably an underlying bed rock in place which may or may not have served as a surface on which placer gold has been concentrated. In this sense, therefore, pay horizons below the clay false bed rock, such as occur at the level of the old second beach, may be sought. There is absolutely no possibility of finding any gravel deposits beneath the bed rock, if this term is used in its technical sense, and exploration seeking to pierce this bed rock is inviting financial disaster.

LEDGES IN PLACE.

This brings us to the second popular fallacy already noted, that the ledges of the district are not in place. Without resorting to the verbal evasion possible, for the word ledge, according to all geologists, means "rock in place," it may be definitely stated that the rocks which outcrop here and there throughout the country are in place. Although the upper few feet of various outcrops are much riven by the frost, and although the normal downhill creep of material through gravitative action has caused a slight migration of material away from the actual outcrop, yet these processes have had so slight an effect on the region that their results are negligible.

The reason why the idea of the dislocated character of the ledges has taken root in the popular mind perhaps lies in the fact that apparently different kinds of rocks occur along the same line of strike. This condition is explained in two ways. In the first place, the most noticeable structure seen in the rocks—namely, cleavage—is not an original structure, but is secondary, and therefore does not indicate the true direction in which the rocks trend. It is consequently to be expected that on the strike of the cleavage different rocks should be encountered successively. The second explanation for the variety of rocks along the strike is that the region is very markedly deformed. This deformation consists both of folding and faulting. In papers now in preparation Moffit[a] describes some of the foldings observed in the Nome and Grand Central region, and the writer[b] notes instances of deformation in the Solomon and Casadepaga districts. In these papers it is shown that intense folding has taken place, coupled with faulting of both the normal and reversed types. The faulting seems to have occurred at two distinct periods, one probably coincident with the metamorphism of the district and another after the formation of the latest quartz veins. Because of these dislocations and crumplings of the crust the geology is very complex and the orderly sequence observed in less deformed regions is wanting.

It is impossible to evade the conclusion that the ledges are in reality in place. Although the geologic structure of Seward Peninsula is much complicated by mountain-building deformation, there is nowhere in the district evidence that the blocks of this portion of the earth's crust have suffered any serious lateral movements since the beginning of the cycle of disintegration and decomposition which has resulted in the formation of the Seward Peninsula placers. Oscillations, it is true, have occurred and are occurring, but there has been no widespread landslide action since the recent gravels were accumulated. In fact, if the paleontologic evidence afforded by shells from the Nome tundra is accepted, there can be no reason for supposing any considerable movement to have taken place since Pliocene time.

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[a] Moffit, F. H., Hess, F. L., and Smith, P. S., Geology of the Nome and Grand Central quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

[b] Smith, P. S., Geology of the Solomon and Casedepaga quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

In this connection it may be of importance to the prospectors for quartz to note that the region is considerably disturbed, so that in mining faults will be encountered which will add to the cost and difficulty of winning the ore. On the other hand, it is believed that the same kinds of rocks may be found in place beneath the cover of moss, slide, and vegetation as those from which the placer gold was derived. The discussion of quartz prospects and of the occurrence of veins from an economic standpoint, however, is given farther on in this paper.

ELEVATION OF ANCIENT BEACHES.

The third erroneous idea which has crept into popular fancy has reference to the places where prospecting for beach deposits may be carried on and especially to the elevation of these ancient beaches above sea level. The misconception has resulted from the fact that the known rich beach back of Nome has maintained a pretty constant elevation for a distance of 5 miles. It is therefore argued by many that the beach at Solomon or somewhere else ought to be sought for at this same elevation. Such a conclusion seems unjustifiable when the various incidents in the history of the beaches are considered. It is difficult to conceive how any process of uplift could have been absolutely uniform over any considerable distance, for the mechanical difficulties of lifting evenly a structure consisting of diverse units of different sizes and weights and balance would be practically insurmountable. Instead of supposing that every portion of the old beach must now be at precisely the same height above sea level, therefore, it is far more reasonable to imagine that only a few points would be at any given elevation and that the majority would be higher or lower. To pass to concrete examples of the present day, one has only to note the elevation shown at Cape York and Nome and the depressed character of the country near Port Clarence to see that all parts of the peninsula have not been affected in the same way at the same time.

To summarize, it is believed that when the third beach was formed at Nome there was a continuous beach around Seward Peninsula just as there is today; that in the intricate history which has taken place since the third beach at Nome was formed some portions of the peninsula have been uplifted higher than others; and, furthermore, that certain portions of the beach have been cut away entirely during the subsequent depression of the region, or that certain portions were preserved beneath the sea where the depression was rapid enough. In view of these facts, it is felt that only by the closest scrutiny of the surface features and of all the available physiographic evidence can the level of the third beach be predicted within reasonable limits.

Prospectors are fast learning that the mere presence of beach material is not sufficient ground for expecting pay, and that there are two essential conditions for forming rich beach deposits. These are (1) a large amount of land waste which has been sorted by wave and water action, so that concentration and reconcentration have been effective, and (2) proximity to mineralized areas from which the valuable metals of the placer may have been derived.

PLACER DEPOSITS.

INTRODUCTION.

The general tendency at the present time in placer work is to reduce the cost of operations by installing mechanical devices for handling the gravels. The miners of the Candle, Council, Kougarok, Nome, Solomon, and Bluff regions have taken advantage of the water resources to such an extent that but little additional water can be obtained, except at a prohibitive price. The conversion of water power into electric power is one of the possibilities of the future. Already on Solomon River a short ditch is in process of construction to furnish water power for generating electricity to run two dredges. A project for damming Salmon Lake and utilizing the head thus formed for the generation of electricity has been discussed for two years or more, but owing to legal complications nothing has been done on the actual construction.

NOME AND GRAND CENTRAL REGIONS.

BEACHES.

As a result of extensive prospecting, it has been found that there is considerable beach wash north of Cape Nome; but it has also been shown that pay gravels are practically wanting. If this is a fact, and there is every reason to believe that it is, the beaches of the more recent past must have looped from the seaward face of the cape; and probably the headland of Cape Nome was a portion of the mainland, at the time of the formation of the third beach, rather than an island. During the last year several paying properties have been located in the neighborhood of Cunningham Creek, and as the height of the pay above sea level is approximately that of the well-known third beach farther west, they are supposed to mark the eastern continuation of that beach. If this is the case, the beach makes a marked swing to the southeast from the point where it reaches the surface on McDonald Creek. This extension of the beach, although rich, is not nearly as rich as the portion earlier discovered between Nome and Snake rivers. Perhaps one reason for this decrease in gold content is that much of the waste of which the beach is formed is derived from the granitic mass of Cape Nome. It has previously been stated that in the Nome-Snake river portion the waste has been derived largely from a region contiguous to a limestone-schist contact. Such is not the case to the east. This relation may be only fortuitous, but it gives a suggestion which may be worth consideration.

The thickness of the overburden along the beach east of Nome River is variable, but is generally in the neighborhood of 100 to 120 feet. This requires a considerable plant, but the difficulties in the way of transportation are not very great. The gold from this portion of the beach seems to be of the same character and appearance as that obtained farther west. In some places it occurs on a false bed rock. The gravels are coarser than those from the third beach between Holyoke and Bourbon creeks, as would be expected if a large part of the waste had been derived from the Cape Nome headland. The larger amount of garnets in the gravels is due to the derivation of the material from the granites and from the large bodies of greenstone which predominate in the Osborn and St. Michael creek country. This beach is probably cut out by the valley of Hastings Creek and the rich placers of the lower portion of this stream may be due to partial reconcentration from the former beach.

West of Snake River the third beach is believed to have been located in the vicinity of Sunset Creek, and considerable gold has been won from this place during the last year. No new features were brought out in this locality beyond the continuation of the old beach to a region in which its presence has been for some time suspected. The western continuation shows that the beach must have extended at one time across Snake River and was subsequently cut through by that stream as it wore down its valley. The gold in this portion of the beach was scattered to some extent by the stream, as it re-sorted the older beach gravels. The rich spots, however, in the lower portion of Snake River, doubtless acquired their original concentration at the time when the Snake River valley was filled with gravels on which the sea was working.

There are some who believe that another beach has been located inland from the third beach, but it has not been possible for the

Survey party to go into the question in sufficient detail to make a statement. It is known, however, that beach material is found at a higher elevation than that of the third beach, so that it is not at all improbable that the sea has stood at a relatively higher level at a time geologically not very remote. This is demonstrated by the fact that marine gravels cover the pay gravels of the third beach.

Work on the third beach has gone on with as much vigor as formerly. Probably half of the entire production from the Nome district comes from this beach. A railroad runs nearly the entire length of the beach, from Sunset Creek to McDonald Creek, so that supplies may be easily transported. A few new pieces of ground have been opened up, but in the main it is evident that the earlier-discovered portion of the beach is nearing exhaustion.

On the second beach but little work has been done during the last year. Between the second and third beaches, however, another beach has been discovered, and this is locally known as the "intermediate" beach. Several large hoisting plants have been erected to handle the gravel. A peculiar thing about this beach, if statements made by presumably reliable men may be trusted, is that it occurs at an elevation of 22 feet above the sea. Such a height would make it lower than the second beach, which lies seaward of it. It would indicate, therefore, a depression of the land subsequent to the formation of the intermediate beach, whereby new deposits were laid down. A rapid uplift must then have occurred, so that the sea took a stand seaward of the second beach, and renewed its attack on the coast.

It was reported that in one of the mines on the intermediate beach a bar had been found which showed the layers of sand and gravel dipping off in both directions—toward and away from the sea. Although this property was examined with considerable care, no evidence to substantiate the report was observed. The facts indicated changeable conditions, but nothing which could be rightfully interpreted as an offshore bar. At this place the bed rock consists of black, graphitic, somewhat quartzitic schist breaking into small rectangular blocks. The pay gravel is made up of but poorly rounded black schist fragments mixed with a good deal of mud. The gravels are very dirty. Above, in the south end of the drift, there is a sand layer which rises very steeply toward the north. In the north end there is a thin layer of muck between the pay gravels and an overlying bed made up of large bowlders. The bowlders are well rounded and some of them are 2 feet in length.

The presence of layers of muck and vegetation in the midst of gravel and slide has been noted in many other places. Thus on the bench west of the middle portion of Dry Creek a drill hole showed the following section:

Section of drill hole west of Dry Creek.

	Feet.
Tundra vegetation and muck	4–5
Subangular fragmental material	30
Tundra vegetation and peat	4
Subangular fragmental material	50
Gravels and creek wash.	

The same thing is also seen on Otter Creek south of the rise in the bed rock.

On the intermediate beach near Center Creek a number of shells have been found. Some are intact, but many of them have been broken into small bits. From their resemblance to certain living forms, it has been suggested by Dall that they lived in water not colder than that on the southern side of the Aleutian Islands at the present day. This gives an interesting insight into the temperature conditions which prevailed while a portion of the coastal-plain gravels of this part of the Nome region were being formed, and serves as a valuable check on the imaginings of those who account for the gold of the tundra as the product of glaciation.

STREAM AND BENCH PLACERS.

The placers that occur in portions of the district outside the coastal-plain province have produced during the last year probably less than one-third of the gold that has been won from the Nome and Grand Central regions. Although forming such minor contributors, these placers, which do not owe their gold concentration to marine action, have yielded during 1907 considerably over a million dollars. The output from this source is obtained from a great number of streams, but the greater proportion comes from Dexter Hill and its environs. During the last year much gold has been recovered from Glacier Creek and its tributaries, from Anvil Creek, especially in its headwater portions, from the upper portions of Dexter Creek and its tributaries, and from the upper branches of Dry Creek.

A region which has sprung into some prominence during the last year, although it has been a producer for a long time, is the Buster Creek country. The completion of a ditch into Buster Creek has given water power under a sufficient head to permit profitable handling of the gravels. During the season of 1907 four outfits have been at work on this creek.

COUNCIL DISTRICT.

The Council district is second only to the Nome-Grand Central region in its gold production. Ophir Creek is the principal center of mining, and on the main stream thirteen different outfits have been at work during the past season. The methods used on the creek are varied. Four properties are being worked by means of hydraulic elevators; two by dredges; two by scrapers, one using both horse and steam scrapers and the other only horse scrapers; one by a steam shovel; one by a derrick and cars; and three by shoveling into boxes.

On the lower portion of Dutch Creek, a tributary of Ophir Creek, one group of claims is being worked by hand labor. None of the tributaries of Ophir Creek above Dutch Creek as far as Crooked Creek are being developed. On Crooked Creek, however, three outfits have been at work during the last season. The gravels are shoveled by hand into the boxes. On Albion Gulch, a tributary of Crooked Creek, two mining camps have been established. One of these is particularly interesting as it is the only hillside placer so far reported in Seward Peninsula. At this place there is a good head of water and the deposit is worked by hydraulicking. The other property is developed by ordinary hand methods.

Near the mouth of Melsing Creek a new steam scraping plant has been recently installed. At least a month was spent in getting the equipment into running order, so that an important part of the season was lost. It is hoped that another year will see the plant operating full time and yielding satisfactory returns. Between the scraper and the mouth of Basin Creek two outfits have been shoveling into boxes. Three or four men have been employed at each place, but no extensive work has been accomplished. At the mouth of Basin Creek a claim is being worked by horse scrapers. The pay gravels are practically at the level of the creek, so there is some trouble in handling the seepage water. Above Basin Creek no prospecting or mining has been done on Melsing Creek or any of its tributaries.

On the tributaries of the Niukluk below Council only a little desultory work has been done during 1907. Above Council two claims have been worked on the central portion of Warm Creek, the gold being won in both by shoveling into sluice boxes. Near Camp Creek some hydraulicking has been done, but the returns from the property are not available. At the mouth of Elkhorn Creek some work was in progress during the earlier part of the season, but later the party removed to Ophir Creek.

The most interesting exploration work that has been done in the vicinity of Council was the testing of the Niukluk flat gravels by drill holes. Near Council there are numerous exposures of bed rock along the river, and in many places ledges came so near the surface that it was originally believed that the gravels which formed the broad flats southwest of the river were only a thin veneer. During the last summer, however, explorations carried on between Fox and Bear creeks, 2 or 3 miles from the Niukluk have shown gravels 250 feet thick in places. Such a depth would carry the bottom of the hole 50 or 60 feet below sea level. It is not believed that this low area was formed by marine erosion, as the narrowness of the cut in bed rock suggests stream work rather than ocean work. As has been pointed out, bed rock outcrops above the level of the Niukluk at Council and also above the level of Fox River at the point where the road from Council to East Fork approaches that stream; yet between these two points the bed rock is at least 200 feet lower.

Local downwarp seems inadequate to explain this feature, for it would be expected that some indications of the depression would appear in the surface forms, if warping took place after the overlying gravels had been deposited. Such surface indications are wanting. It seems more probable, from the slight evidence at our command, that the region is a stream valley and that the low areas revealed by drilling probably mark an old channel. Subsequent to the formation of the channel depression took place, whereby filling of the more ancient valley was effected. At the close of this stage the land probably stood at a lower elevation than it does at present and the surface of the flat, southwest of Council, was the flood plain of the old Niukluk River. A later episode, marked by the physiography of the region, was a slight uplift whereby the rivers were allowed to incise their courses 20 to 40 feet below the old flood plain. The duration of the different stages is of importance, for if the channel which has been disclosed by the drill hole was made in a short time the distribution of the gold and the width of the profitable ground would be different from those features produced in a region which had been stable for a long time. The facts known are still too meager to permit final interpretation, but the occurrence of bed rock so near the surface in certain places in the flat suggests a canyon character for the old valley rather than a more mature form.

Further light on this question is afforded by the record of a shaft 102 feet deep which was sunk near Mystery Creek about halfway between its junction with the Niukluk and the point where it leaves the hills. A short distance above this shaft bed rock is practically at the surface in the creek, being covered only by a thin mantle of gravels, not more than 4 feet deep. The gravels cut by the shaft were but slightly waterworn, and yet small shells in a perfect state of preservation were found. Unfortunately the shells were not kept and it is not known whether they were fresh-water or marine forms.

It is evident that from the very fragmentary facts now known about this region it is unsafe and unwarranted to draw far-reaching conclusions, yet a setting forth of the known conditions and surmises may be of assistance in solving some of the problems. Residents in the district, knowing the fabulous riches of the beaches at Nome, are anxious to prove marine occupation of the Niukluk flats. The whole question, however, is one which depends not on salt water or fresh water, but on the work accomplished. No matter what the water was that occupied the area—river, estuary, lake, or bay—if no concentration of the gravels occurred, no gold placers could be formed.

From the topography of the country surrounding the flats it has seemed that the possible connection with the ocean would be so narrow that water sorting would be reduced to a minimum. To consider a concrete example, let us take the shaft near Mystery Creek. This shaft must have reached within 25 or 50 feet of sea level; in other words, if the popular idea that the flats near Council were occupied by the sea is correct, the region could not have been depressed more than 25 or 50 feet below its present position. Suppose all the unconsolidated superficial material which now forms the flats of the Niukluk Basin were removed and the region sunk 50 feet; it must be evident that the connection of this basin with the ocean south of Steamboat Creek would be so narrow that the conditions would be similar to those at Imuruk Basin. Anyone familiar with that basin knows that although it is an arm of the sea and its water is salt, no considerable beach concentration is taking place.

SOLOMON AND CASADEPAGA REGIONS.

BEACHES.

Prospectors aware of the similarity between the coastal plains at Nome and Solomon have begun to turn their attention to the latter district, and already scores of holes have been sunk to explore the tundra gravels. Up to the close of the summer of 1907, although beach material was encountered in many places, no pay had been located. The facts gleaned from the Nome tundra have been so driven into the minds of prospectors that they are inclined to give too wide application to the details. As has been mentioned in a previous paragraph, the hope of finding pay beaches at the same elevation throughout Seward Peninsula is fallacious.

The greatest amount of exploration has been carried on west of Spruce Creek, and during the last year over a dozen parties have been engaged in the search. A few sections may be of interest as showing the different kinds of material encountered in shafts 2 miles inland from the shore, just west of Spruce Creek. Of these shafts the second is 100 yards south of the first, the third 100 yards south of the second, and the fourth 75 yards southeast of the third.

Sections of shafts west of Spruce Creek.

1.

	Depth.	Thickness.
	Feet.	*Feet.*
Blue clay with large amount of ice	15	15
Slide rock consisting mainly of chlorite schist	30	15
Clean river sands, becoming coarser toward bottom	48	18
Yellow and red gravels	50	2
Fine dark sand	54	4
Black clay with some slide	58	4
Fine light-colored sand	62	4
Black peaty material containing some fragments of wood which look like spruce	64	2
Fine sand and black mud	67	3
Black clay containing well-rounded pebbles 1 inch in diameter	70	3
Fine iron-stained beach sand with schist and black quartz pebbles	73	3
Bed rock: black schist.		

2.

Blue clay with much ice	8	8
Reddish, fairly rounded gravels like the material between 30 and 48 feet, hole 1	20	12
Alternate layers of black mud and beach sand, not very gritty	40	20
Light-colored yellowish sand	41½	1½
Decomposed peaty material with some wood fragments	42	½
Black sand, mud, and quartz pebbles	50	8
Schist bed rock.		

3.

Blue clay with much ice	8	8
Slide with some water-made pebbles	20	12
Black, dirty, fine-grained sand	26	6
Clay with some reddish-yellow gravels	29	3
Light-colored beach sand	32	3
Black peaty material with some quartz pebbles	35	3
Gravels of black angular schist with some well-rounded quartz pebbles	43	8
Bed rock: black schist.		

4.

Blue clay with much ice	8	8
Black, somewhat angular fragments with some well-rounded pebbles	23½	15½
Yellowish sand with very fine small pebbles; looks like sea sand	27½	4
Decomposed peaty material with strong, offensive odor	30½	3
Black, dirty wash with some very well rounded beach pebbles. One of the pebbles was 8 inches in longest dimension	38½	8
Bed rock: black schist with some limy layers.		

The most interesting features brought out by a study of the foregoing sections are the thickness of the gravels and the presence of certain comparable beds. There is a marked seaward thinning of the deposits; thus in the first section the depth to bed rock is 73 feet, whereas in the last it is only 38½ feet. Not only is this true of the section as a whole, but also of some of the individual layers; for example, the blue clay and ice, which is 15 feet thick in the first section, is only 8 feet thick in the last. Certain members, however, show no constant variation in thickness.

One of the most marked beds, which seems to be rather constant throughout the area explored by the four shafts, is the layer of black peaty material. This bed occurs pretty constantly at an elevation of

10 feet above bed rock, and although there is some variation in thickness, the average is between 2 and 3 feet. It is uncertain what origin is to be assigned to this layer of vegetation. It may represent a land surface which has been submerged or it may be the accumulation of mud and marsh vegetation in a salt-water lagoon. The presence of spruce fragments is not conclusive, for logs may have been washed into ancient lagoons just as they are into those of the present day, or, on the other hand, the spruce may have grown on land near the point where the fragments are found. A careful study of the vegetable remains might shed much light on this point. Although no definite conclusion has been reached, it is tentatively suggested that the theory of tidal-marsh origin has many points in its favor.

CREEK AND BENCH PLACERS.

The Solomon and Casadepaga region produced a small percentage of the total placer output of Seward Peninsula for 1907. The greater part has been taken from Solomon River and its tributaries, only a small portion coming from the Casadepaga drainage. At the dredge near Oro Fino work has gone on even more actively than formerly, and even when almost all other work in the district had ceased owing to the cold, it was able to continue production. The lengthening of the season by even a day or two means a considerable increase in profit. The main new development at the dredge was a project for the generation of electricity by water power. This project was commenced only in the latter part of the season, but it is hoped that another year will see the entire plant run by electricity. The owners report that during the last year a large amount of a heavy iron mineral has been caught in the boxes which adds considerably to the work of cleaning up. This material on examination proved to be magnetic iron oxide, or magnetite. Much of it is in pieces an inch or so in length. No locality from which magnetite of such size could be derived is known in the area drained by Solomon River. The theoretical consideration of these fragments might have important practical value in giving an insight into the way in which the gravels were accumulated.

On Shovel Creek much work has been in progress during the season of 1907 as far as the mouth of Mystery Creek. In this area some technical problems have received a novel treatment, but no important scientific facts have been gleaned. Four or five parties have been at work on Mystery Creek below Problem Gulch. A new ditch line from Bonanza and California creeks which is nearing completion will soon reach this area, so that a more abundant water supply at a considerable elevation will be available. Above Mystery Creek no mining has been done on the main stream. On West Creek seven or eight parties have been mining the creek and low bench gravels. The most productive work, however, has been near the mouth of the creek. At this place a bucket dredge running on a track has been working double shift a large part of the summer. The section of the gravels shows a thickness of about 6 feet. The upper portion is rather fine creek wash consisting mainly of schist fragments. The lower part is as a rule coarser, and though many of the fragments are well rounded by water, numerous large, angular blocks 2 or 3 feet long are encountered. On Kasson Creek a continuation of earlier work has been in progress near the mouth of the stream. The limestone bed rock of this portion of the stream is much fissured, and this condition, added to the entire disappearance of the water, makes the winning of the gold a difficult problem.

Above Shovel Creek on Solomon River two outfits have been at work near the mouth of Penny Creek, but on Penny Creek itself little work has been done except at the junction with Minnesota Creek. One prospector has been located on the very summit of the saddle between Minnesota and Kasson creeks. Above Penny Creek the next group of mining operations have been on the Solomon River benches near the mouth of Quartz Creek. Between this place and Big Hurrah Creek some mining was in progress during the middle of the season, but work here began late and closed early. On Big Hurrah Creek mining was carried on most actively near the mouth, but work extended all the way up to Tributary Creek. Above that point, however, no productive work was accomplished. The elevators at the mouth of this creek did not commence work until late in July, and owing to the short season the production was relatively small.

Between Big Hurrah Creek and East Fork a little work has been done on some of the small side streams from the east and also just below East Fork. On East Fork and its tributaries no mining has been done during the last year. Above East Fork, near the mouth of Jones Creek, an elevator has been in successful operation. Near Winnebago Creek horse scrapers have been in use. On Butte Creek there has been a little mining, especially on South Fork. At this place the geology is very complex. A heavy white limestone which forms the divide between Winnebago Creek and South Fork is folded down so that for a considerable distance above the productive ground the stream runs practically on the contact between it and the underlying chloritic schist. Some quartz has been observed apparently filling nearly vertical gash veins near the contact, but these veins show no evidence of metallic mineralization.

Near the mouths of Johns and Coal creeks on the Solomon River flood plain some mining has been carried on recently, but on a small scale. On Coal Creek and its tributaries no mining has been done except on Fox Creek. Here, however, only one man has been at work, so the returns were small. The pay gravels were located upstream from the limestone which occupies the middle part of the creek's course. Between Coal Creek and the head of Solomon River work during the last year has been mainly of the assessment type, and the production is consequently negligible.

In the Casadepaga drainage area but little real mining work has been done recently. A mile or so above the mouth of Bonanza Creek, on the main river, one man has been mining gravels a few feet above the water. Most of the gold is coarse, but the returns are not adequate. On Dawson Creek, near the mouth, are some bench gravels which have been mined off and on during the summer. On Big Four Creek, about three-fourths of a mile above its mouth, one man has been doing a little work on the stream gravels. Difficulty has been experienced at this place on account of the depth of the gravels and the impossibility of taking care of the seepage water. No other work has been done on Big Four Creek, although in previous years several outfits have been located on the main stream and its tributaries. The region would appear favorable for further prospecting, as the complex deformation and dislocation that the rocks have undergone would undoubtedly allow easy passage for mineralizing solutions. Also, if there is truth in the idea that the contact between the heavy limestones and the schists is a zone of mineralization, there are, particularly in the Birch Creek country, many places where this contact can be followed for long distances. Not only does heavy limestone appear here, but also the continuation of the black, graphitic, quartzitic slate belt which has been described as present in the vicinity of the Big Hurrah mine.

Between Big Four and Penelope creeks three or four small outfits have been mining some of the low bench gravels of the main stream, but the production from this source is small. On Penelope Creek some active work has been in progress and the season has been satisfactory. Mining on this stream has centered on a group of claims about a mile above the mouth. At this place, to the west of the stream, a shaft has been sunk for 93 feet through creek wash and gravels. The low channel thus disclosed would seem to mark the deeper valley of Penelope Creek, which conformed with the previous deeper valley of the Casadepaga. The bed rock of this creek is almost exclusively schist.

Nearly opposite Penelope Creek Goose Creek joins the Casadepaga. An interesting experiment in the utilization of water power for scrapers is in progress on claims near the lower part of this creek. As this system undoubtedly furnishes power at a low cost its introduction may follow in other districts. The gradient of the stream is, however, so low that the tailings must be rehandled. The gold is mostly fine and much worn. At present the creek gravels only are being worked, but some of the lower benches which have been examined yield fair prospects. Work is going on at but one other camp on Goose Creek, located 4 or 5 miles above the mouth of the stream. Only a small crew has been employed. On Quartz Creek, the largest tributary of Goose Creek, a party has been at work about half a mile above the mouth. Here the bed rock is schist, but upstream a belt of limestone, rather flat lying, occupies the creek bed for nearly half a mile. Much of the gold is rather coarse, some pieces worth from $5 to $8 being found. The depth to bed rock changes rather abruptly; in some places it is only 3 feet below the surface, but in others it is 10 feet. At the place where bed rock lies nearest to the surface, no gravels intervene between it and the muck and vegetation, but where the bed rock is deeper there is a considerable body of gravel. It is stated, however, that the gold values are just as good on the higher bed rock as on the deeper. The gold has penetrated far into bed rock along the crannies and fissures, so that in many places it is necessary to take up 2 feet of the rock in order to win the pay. Some work has also been done on the first tributary of Quartz Creek from the east. The course of this creek has been largely determined by the contact between a heavy limestone and chloritic schist. There are many limestone caverns here which make the economical washing of the gravels a serious problem. The gold from the side stream is coarse and fairly sharp, and fragments of quartz are attached to many of the nuggets.

The next upstream tributary of the Casadepaga on which mining work has been done is Canyon Creek. The present stream flows in a comparatively recent valley incised 10 feet or so in older creek gravels. Practically no values are carried by the modern gravels. The best pay occurs in the benches, especially those north of the stream. These gravels are rusty and overlain directly by the muck and vegetation of the tundra. The bench gravels seem to be more thoroughly rounded than those of the present creek. The gold is bright and not much worn and on the whole medium coarse. The bulk of the gold is in flat pieces, from a fraction of a cent up to 50 cents in value. Nuggets worth up to $2 have been found, but they are rather uncommon. Some of the large pieces show quartz attached to the gold. The bed rock throughout the productive portion of the creek is almost exclusively chloritic schist. In the schist are numerous quartz veins, which probably belong to the earlier series. Work on the group of claims has been carried on by pick and shovel methods, but late in the season a hydraulic elevator was installed, and it is hoped that another season will record large returns from these properties.

On Banner Creek, a tributary of the Casadepaga from the east above Canyon Creek, some mining has been in progress about a mile above its mouth. This portion of the stream flows over the contact between a limestone and a schist. The placer is a creek placer. Only two men have been employed and they have worked but a portion of the season. On Lower Willow Creek several camps have been established, but not much production is to be credited to this creek. Besides two or three creek claims 3 to 4 miles above the mouth some work has also been done on the benches, which are most notably developed north of the stream. No work has been done on the upper portion of Lower Willow Creek.

At the junction of Ruby Creek and the Casadepaga a party of four have been hydraulicking the gravels with water brought by a ditch from the upper part of Ruby Creek. The gold at this place is almost entirely bright gold. This is the usual character of the Casadepaga gold because of the revival of dissection by uplift. The uplift has, as a rule, affected the smaller side streams less, and consequently much of the gold they carry is rusty. This is believed to be the real reason for the difference between the Ruby Creek and Casadepaga gold, instead of the one suggested by many prospectors, that they are two different "runs." Although remnants of previous mining may be noted throughout the length of Ruby Creek, the gold output for the last season has been derived entirely from the lower two claims. No mining has been done on the Casadepaga above Ruby Creek during 1907. A party, it is true, has been engaged in prospecting the higher benches on the northern slope of the valley, opposite Monument Creek, but the work was simply that of testing the ground.

Development in the entire Casadepaga region has been much hampered by the lack of adequate transportation facilities. It was believed that with the completion of the railroad to Penelope Creek in 1906 this difficulty would be removed. The season of 1907, however, has shown that such is not the case. Until late in the summer no trains were run across the Ruby divide, and then they were run only once or twice a week. Early in September train service beyond East Fork on Solomon River was discontinued. Even in this short season the charges ($50 a ton for freight and $5 apiece for passengers) for the 30-mile run to Penelope were so high and the protection given goods in transit and while waiting delivery was so inadequate that few miners could make use of the railroad. During the last year no additional track has been laid.

OTHER PORTIONS OF SEWARD PENINSULA.

It has been noted that no geologists of the Survey visited the Kotzebue Sound, Bluff, Kougarok, or Port Clarence districts during the last season. For this reason the report on these districts is wanting in details.

KOTZEBUE SOUND.

During the year 1906–7 about 9 per cent of the production of Seward Peninsula came from the region around Kotzebue Sound, known as the Fairhaven precinct. In this area there are three mining centers—one in the vicinity of Candle, one in the basins of the streams having their mouths near Deering, and the third on Bear Creek. Two large ditches and one smaller one have been completed this year, one for each of the mining centers, so that the problem of water supply has been more or less satisfactorily solved. An account of these and several smaller ditches may be found in a paper by F. F. Henshaw elsewhere in this volume.

At Candle there has been a continuation of the work of previous seasons, and prospecting has been carried on more extensively on some of the bench deposits. The gravels on the benches vary much in thickness and in elevation above the present stream. Some of the benches on which pay is reported are said to be about 50 feet above the river and to carry gravels from 15 to 30 feet thick. The opening up of these deeper gravels will undoubtedly have a beneficial effect on the district, for it will permit winter work. At the present time only a few men can be given permanent employment. The opening of the Candle ditch will also help the country, for in the past the lack of a water supply under sufficient head has been a serious detriment.

In the Inmachuk basin there has been a decided increase in the amount of winter mining. Where the summer season is as short as it is in the Kotzebue Sound region, it is of great importance for the miners to be able to work during the winter. In shallow creek diggings such work is impossible; but in many places the gravels are from 20 to 40 feet thick and lend themselves to advantageous development during the winter. No new mining developments, with the exception of ditch building, have occurred in the Inmachuk basin within the last year.

Bear Creek, the third mining center in the Kotzebue Sound region, is east of the range between Kiwalik and Buckland rivers. Bear Creek itself is a tributary to the West Fork of the Buckland. It lies about 40 miles from Candle. The productive ground is confined to a few claims and only a small force of men has been employed in the district. The production for this year has been rather small, because much of the season has been spent in ditch building. It is believed, however, that in another year the production of Seward Peninsula will receive an appreciable increase from this district. The isolation of this camp, however, makes the cost of supplies so high that it will not be able, for some time, to compete with more favorably situated fields.

BLUFF.

Considerable excitement has been awakened during the last year by the finding of an ancient beach deposit below sea level near Bluff. This strike has been looked on as a most unusual and inexplicable occurrence, not so much on account of the finding of pay, but because the deposit occurs below sea level. To one who has studied the Nome beaches, such a fact ought not to be surprising. The beaches already known bear witness to the oscillations that the region has undergone. Moreover, drill records which have been made at the mouth of Snake River show bed rock in places several scores of feet below the present sea level, with beach material above. The deep gravel-filled valleys of Nome and Snake rivers also show that the land once stood relatively higher with respect to the sea than it does at present. If such things are known to have taken place in the past in the Nome region, there is no reason why they should not also have occurred in other places.

To return to the Bluff region, there are certain facts that should be borne in mind by prospectors. The fact that, at Bluff, a certain beach occurs below sea level is by no means proof that it connects with a beach below sea level somewhere else. This point has been emphasized in other portions of this report (see pp. 212–213), but it is of such importance that it should be reiterated. At the present time there is no conclusive reason for connecting the newly discovered beach at Bluff with any of the beaches at Nome. Careful and systematic tracing by studying surface forms and by unraveling the details of the past history of Seward Peninsula is the only way in which the various beaches can be projected and correlated one with another.

The result of the uncovering of this new beach has been a notable increase in the production during the last year, so that probably almost as much gold has been taken from this small area as from the whole Fairhaven district.

Although more or less worn, the gold seems to be mainly of local origin. In this connection the presence of mineralized zones, as has been pointed out on page 239, is of importance.

KOUGAROK REGION.

The Kougarok was visited and described by Brooks[a] in 1906, and but few additional notes are available. Mining during the last year has been on practically the same scale as formerly. The completion of the Seward Peninsula Railway from Nome to Lanes Landing or

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[a] Brooks, A. H., The Kougarok region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 164–181.

Shelton, in the late fall of 1906, has been of much benefit to the district, for it has provided quick and relatively low-priced transportation to a district which was practically inaccessible except by small boats in summer or by sleds during the winter.

Mr. F. F. Henshaw, who spent considerable time during the last year in the Kougarok district, has kindly furnished notes on the mining operations.[a] On Coffee Creek five or six men have been employed. On Dahl Creek some work was done before July 10 and after August 20, but probably not more than ten men have been mining during the season. The next productive stream is Windy Creek, where four men have been ground sluicing. Still farther upstream, in the vicinity of Left Fork, a small tributary of the Kougarok, three men have been doing a little prospecting. On North Fork there has been no productive work except below the mouth of Eureka Creek, where two men have been shoveling into boxes and ground sluicing. Still farther upstream three men have been at work on a bench of Kougarok River just below Arizona Creek. Practically only prospecting work has been done on Henry Creek during the last year, two men being employed. Just below Henry Creek, at the mouth of a small tributary from the east, two men have been mining. On Taylor Creek an outfit of two men has been shoveling into boxes at the mouth of Solomon Creek, about 6 miles east of the junction of Taylor Creek and the Kougarok. Two men have been mining on Macklin Creek. On the main river two outfits of four and six men each have been mining creek gravels near the mouth of Macklin Creek. Four others at the same locality have been shoveling in bench gravels that occur at a small elevation above the river. Probably six or seven men have been prospecting or washing gravels on a small scale above the mouth of Macklin Creek. In this portion of the river only two of the side streams have yielded pay. These tributaries are both small. On the lower, Trinity Creek, which enters 2 miles above Macklin Creek, two men have been working the creek gravels. On Mascot Gulch, which is about 2 miles above Trinity Creek, a party of two men has been working whenever water was available.

Although lying outside the Kougarok drainage basin, the tributaries of the Noxapaga heading in the Kougarok divide have generally been considered as belonging to this district. In 1907 the only two streams from which any production was reported were Garfield and Boulder creeks. On the former five men have been employed and the reports are encouraging. On the latter four men have been mining, but no returns are available.

From the foregoing statements it would appear that about seventy men have been mining in this region during the last year. None of the operators have done any extensive work, the mining being generally carried on by pick and shovel methods, so it is doubtful whether more than 50,000 yards of dirt have been handled. In the above enumeration no account of the men engaged in ditch building has been taken. Over a hundred men have been employed in this work, but they have contributed nothing to the gold output.

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[a] The ditch-building operations are described in Mr. Henshaw's paper on the water supply of the Nome and Kougarok regions, elsewhere in this volume.

PORT CLARENCE REGION.

The Port Clarence region has not been visited by members of the Geological Survey for a number of years and but few new notes about it have been collected from mining men. For several years the region received but scant attention from the outside. Now, however, it has shown increasing activity and mining promises to be pushed more energetically. To the north of Grantley Harbor and Port Clarence there are two areas in which most of the mining is being done. One of these is near Sunset Creek and the other is in the American Creek basin. On Sunset Creek a ditch line over 30 miles in length has just been completed, so that in August, 1907, the water was available for mining. Owing to the late turning on of the water, much of the season was lost for productive mining. The gravels at this place are between 6 and 8 feet deep, and it is planned to handle them with a hydraulic elevator. It is expected that the work will be vigorously pressed in the future.

In the American Creek district the most active mining work has been on Windy Creek at the mouth of Budd Creek, but only one crew of five or six men has been employed. The completion in the late fall of a large ditch will probably give a great impetus to mining in 1908 in this region. The ground to be worked with water from the ditch is about a mile downstream from the junction of Budd and Windy creeks.

South of Port Clarence the main productive area is in the Bluestone basin. Heretofore work has been greatly impeded by the lack of sufficient water, but this deficiency is being remedied by ditch construction. Gold Run is the most important tributary of the Bluestone, and it is from this creek that most of the gold obtained in 1907 has come. There have been about eight different outfits in the Bluestone country, ranging from camps of fifteen men down to individual prospectors.

LODE MINING.

During the year 1906–7 there has been increased activity in prospecting for lode mines, and on the whole the work has given a healthy stimulus to the district. Nowhere, however, except at the Big Hurrah mine, has the work progressed beyond the prospect stage, so that the output of the peninsula has not been materially affected.[a] The holders of many of the veins, however, have placed an unreasonably high value on their properties and this discourages investment by outside capital. A few thousand dollars is ample reward for the pluck and luck which locates a promising ledge, but several hundred thousand dollars should be the prize reserved for the man who makes a producing mine from the unproved project. A realization of this fact is important if outside capital is to be invested, for business men will not accede to the fabulous valuations set on the undeveloped properties scattered through Seward Peninsula.

GOLD.

GENERAL CONDITIONS.

The fact that mineralization is widespread in this portion of Alaska is being more and more conclusively proved each succeeding year as prospectors turn their attention to the search for veins. The lode deposits that are attracting most attention at the present time in Seward Peninsula are those in which gold is the main or most important metallic mineral. This is necessarily true, for all the other metals require more elaborate plants and the products must be disposed of in a constantly fluctuating market. The other metals are sought, but only those which promise to return some values in gold are likely to be of immediate importance. Thus, although antimony is found in some of the lodes, copper in others, and bismuth in still others, the owners are counting on defraying some of the expense incident to mining by the returns from the accessory gold content.

There are two main types of veins. In one the filling is mainly quartz with the values carried as free gold; in the other the filling is mainly quartz, but the gold occurs chemically combined with sulphur or some other element. Although the question has not been thoroughly studied it is believed that the veins in which free gold is the principal valuable mineral have been formed later than the larger part of the metamorphism and are therefore not very badly sheared or altered. From a geologic standpoint the places where veins occur may be summarized as follows: In the black quartzose slates, near the contact between two different lithologic types, and in the chloritic schists. The importance of these geologic conditions in the production of mineralized veins, measured by the facts at present known, is indicated by the order in which the different kinds are named. The veins in the black slates are generally destitute of sulphide mineralization, but many of those of the other two classes carry sulphides. Some of the contact deposits occur near the contact of heavy limestone and chloritic schist and others near the contact of heavy lime-

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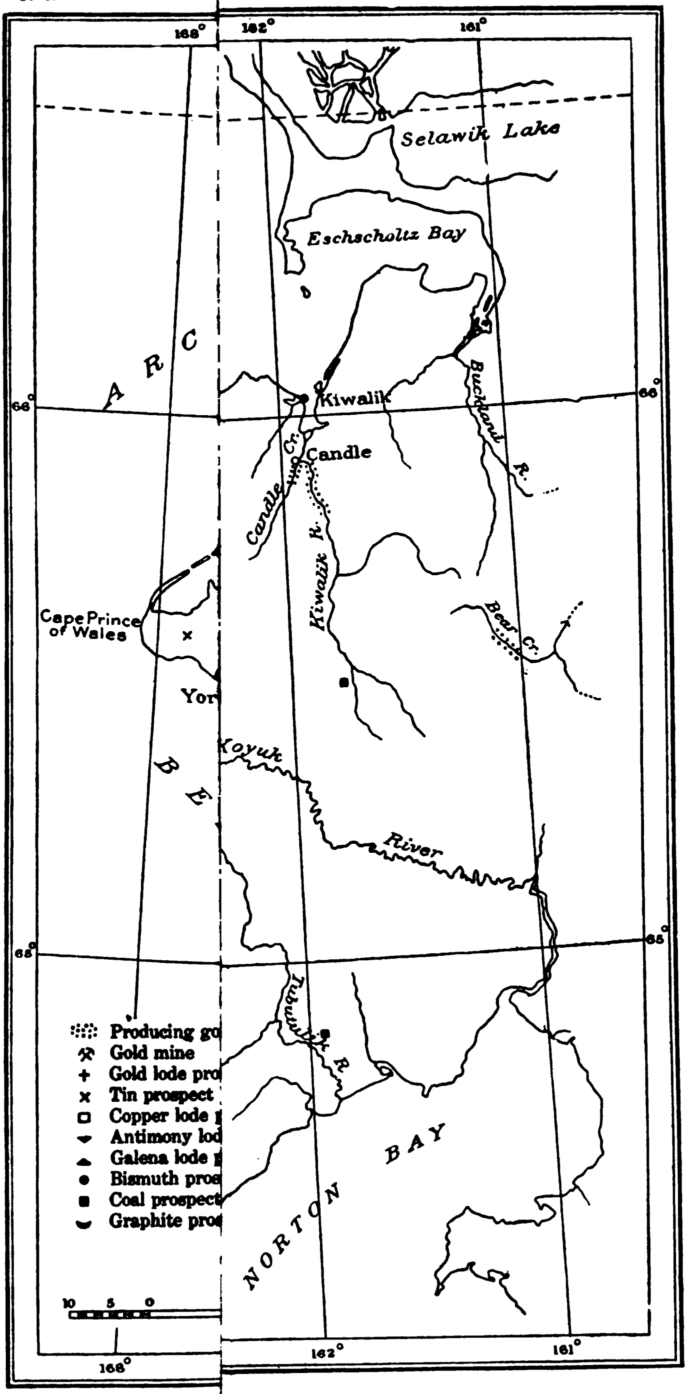
[a] In this paper the tin developments are not considered, as they are treated in detail by Adolph Knopf in the succeeding paper in this volume.


168°
162°
161°
Selawik Lake
Eschscholtz Bay
A R C
Kiwalik
Candle
Candle Cr.
Kiwalik R.
Buckland R.
Bear Cr.
66°
Cape Prince of Wales
Yor
B E
Koyuk River
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Tubutulik R.
NORTON BAY
Producing go
Gold mine
Gold lode pro
Tin prospect
Copper lode
Antimony lod
Galena lode
Bismuth pros
Coal prospect
Graphite pros
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stone and greenstone or feldspathic schist. No productive veins have thus far been found in the greenstones and attendant schists or in the granites, although these rocks are distributed more or less widely through Seward Peninsula.

It may be of interest to mention the various places where lodes have been reported. It has not been possible for members of the Survey to visit all the different properties enumerated, so the list probably includes veins which have not the possibility of an economic future. It has been the object, however, to exclude as far as possible those locations in which no serious prospecting and development work have been done. The map (Pl. V) indicates the location of the various prospects described on the following pages.

It is realized that overemphasis may have been placed on some properties which have been producing but little, and that not enough space may have been given to others which because of their remoteness or for some other reason have not come to the writer's attention, yet it is believed that the following notes may serve as a summary of operations up to the close of 1907. To those outside the district these notes will indicate the tendency and scope of present work, and to those within its limits they will record what has been done and point out certain needs for further systematic development.

NOME AND GRAND CENTRAL REGIONS.

The Snake River basin seems to be one of the more heavily mineralized areas in the Nome region. This is interesting in connection with the fact that the richest portion of the ancient beaches occurs in the part of the tundra nearest the former mouths of this stream and its tributaries. In many places, however, the bed rock itself on which the beach material is deposited shows evidences of mineralization; thus between Holyoke and Saturday creeks veins which are reported to assay well have been found intersecting the schists.

As it is believed that the mere statement of localities where veins have been prospected in the Snake River region may be of some value to prospectors, it is proposed to note briefly some of the reported lodes, taking the main river and each of its tributaries in succession from mouth to head.

On Dry Creek most of the exploration for lodes has been near the upper part. Near East Gulch there is a contact of the heavy limestones and the schists and at this place a shallow hole has been sunk on a calcite vein. The evidences of mineralization are very slight, consisting only of a small amount of iron decomposition products. A vein has also been encountered in sinking an 80-foot shaft in placer ground in the upper portion of Dry Creek, and another prospector near the same place reports ore carrying from $5 to $15 a ton in gold.

Veins are also reported on Bear Creek, a stream whose course is determined by the limestone-schist contact.

On the west side of Anvil Creek, at an elevation between 300 and 400 feet, there is a quartz lode on which a small amount of work has been done. The country rock is a black, somewhat quartzitic schist which is much wrinkled. The folding that has taken place seems to have formed open spaces in which the quartz has been deposited. The quartz is very lean and no metallic minerals are visible. Three-fourths of a mile to the north there is another quartz vein which has been opened by an adit about 15 feet long. The general trend of the vein is north and south, with a westerly dip, but it is so brecciated that its true structure could not be determined with precision. In places the quartz shows well-terminated crystals an inch or so in diameter, and the vein is believed to belong to the later series. Although the quartz is considerably stained with iron there is no other sign of mineralization, and as no work had been done on the property for some time it seems probable that the returns from the work already done were not sufficient to warrant further outlay. A short distance above Perkinsville on Anvil Creek there are numerous quartz stringers from an inch to 8 or 10 inches in width. These occur in a black, finely fissile chlorite schist and although some of them cut across the schistosity, in general they appear to lie parallel to it. The stringers are somewhat bent and folded with the schist, and like it they stand nearly vertical and are badly fractured and minutely dislocated. The veins carry some iron pyrite scattered throughout in small stringers and vugs. Assays show a small gold tenor. In form the quartz veins are generally lens shaped and most of them are not more than 100 feet in major dimension.

The Anvil-Glacier divide shows numerous veins, some of which have given promising assays. Near the point where the road crosses this divide a shaft has been sunk for almost 100 feet in a schist which is intersected by a network of quartz veins. Some selected fragments of the quartz show free gold. North of this shaft on the same divide are numerous calcite veins, but so far no ore body has been found in veins of this type. The quartz veins in this neighborhood, however, carry a small gold content. One such vein occurring near a schist-limestone contact, according to Moffit,[a] has a thickness of 1 to 2½ feet and can be traced for a distance of about 100 feet.

Near the mouth of Snow Gulch on Glacier Creek there are numerous quartz veins, picked specimens from which yielded, according to Moffit,[b] $9 a ton in gold. The schist in the immediate neighborhood of these veins is in places heavily impregnated with pyrite and probably carries gold also.

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[a] Moffit, F. H., Geology of the Nome and Grand Central quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

[b] Op. cit.

This belt of mineralization extends over toward Rock Creek and shows the same features of heavy disseminated mineralization. Near the wagon road leading to Rock Creek there is a shaft said to be 70 feet deep which has been sunk on a series of intersecting quartz veins. At this place, in addition to the ordinary iron pyrite, some arsenical pyrites have been found and also an intimate mechanical mixture of copper and antimony sulphides.

Above Rock Creek on Snake River the next veins which have been prospected occur near the mouth of Boulder Creek. At this place there are a number of small veins, the largest of which, according to Moffit,[a] is not over 5 inches thick. These all carry some gold, although the assay returns indicate too low a tenor to be profitable under present conditions. Near Goodluck Gulch also there are numerous quartz stringers showing mineralization—mostly iron pyrite or its decomposition products. The quartz shows much crushing. On Pioneer Gulch there is some mineralization which has led to considerable prospecting during the last summer. The quartz at this place is reported to carry considerable free gold, but the stringers are very narrow and would be difficult to mine.

Above Boulder Creek three leads have been found, but the most important is the one near the head of Goldbottom Creek. The vein at this place has been known for some time, as the ground was staked four or five years ago, but only within the last two years have exploration and development been active. The vein is located near the contact of the heavy limestone which forms the larger part of Mount Distin with the underlying schist to the west. It is reported that the vein has been traced for a distance of a mile and that everywhere it is parallel to the limestone-schist contact. Such a character would suggest a gentle dip, which would make the cost of operating rather high. At the present time the ore is treated in a 3-stamp mill the power for which is afforded by water delivered by a ditch about a mile in length. It is understood, however, that a gasoline plant is to be installed so that work may be kept up continuously throughout the year. This prospect was not visited by any member of the Survey during 1907, but from apparently reliable information it is believed that this group of veins belong to the class of contact deposits which are so common throughout a large part of Seward Peninsula, but which so far have not yielded much return.

On Nome River and its tributaries but few veins carrying gold as the main metallic mineral have been uncovered. On Osborn Creek a quartz vein which occurs near the contact of a greenstone and mica schist has been slightly developed. Assays of this ore are reported to show a great variation in gold content, from $4 to over $40 a ton. Associated with the gold is a little copper sulphide, which on weathering imparts the characteristic copper-carbonate stain to portions of the vein. On Banner Creek a vein, said to be 8 feet wide, with both walls well defined, is reported, but was not visited by any member of the Survey. Several small limestone bands cross Banner Creek and the lode may occur near the contact of the schists and limestones, but this fact could not be ascertained. The ore is reported to show a small amount of free gold in the quartz. Near Mormon station, on the Seward Peninsula Railway below Dorothy Creek, a vein has been found more or less impregnated with iron pyrites and a little copper pyrite.

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[a] Op. cit.

In the Kigluaik Mountains and in the plateau region to the south there has been some prospecting for quartz lodes. On Stewart River a quartz lead which is said to be 4 feet wide has been located and a tunnel has been started, but as yet nothing is known definitely of the property. Some prospecting has been done on Buffalo Creek and on the upper portion of Hudson Creek, but no permanent force has been at work, so the returns presumably were not satisfactory. On Cobblestone River on the north side of the mountains some free-milling quartz has been discovered, but its value was not learned. On the first tributary from the east to Grand Central River above Nugget Creek two men have been at work uncovering a ledge of auriferous pyrite. This lead is reported to be a series of quartz stringers, some of them 3 feet in width, which conform more or less closely to the cleavage of the black graphitic schists that form the country rock at that place. The quartz contains a considerable sprinkling of pyrite and the outcrop is heavily iron stained.

SOLOMON AND CASADEPAGA REGIONS.

In the Solomon region is located the Big Hurrah quartz mine, which is the only producing lode mine in the entire peninsula. This mine has been described in some detail by Collier.[a] It has been in almost constant operation since its discovery in 1900, and although the ore is known to be of low grade, its total production is important. There are several veins at this place, but the middle one has been most extensively worked. At the present time the shaft is down more than 250 feet and several hundred feet of drift are turned off. The veins occur in a black, hard, somewhat graphitic, quartzitic rock which breaks into more or less rectangular fragments. This rock occurs in a rather narrow belt, a mile or so wide, extending from Uncle Sam Mountain to the head of Solomon River. The country rock is much fractured and is thoroughly intersected by quartz veins or stringers from a fraction of an inch up to several feet in width. The veins have all been more or less crushed and crumpled, but they have not been so greatly deformed as to lose their continuity. The amount of deformation which they have suffered suggests that they belong to the later series of quartz veins, which were formed either coincidently with or later than the second period of metamorphism that the region has undergone.

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[a] Collier, A. J., Hess, F. L., Smith, P. S., and Brooks, A. H., The gold placers of parts of Seward Peninsula: Bull. U. S. Geol. Survey No. 328, 1908, pp. 228–231.

A striking feature of the quartz in the Big Hurrah mine is the absence of much sulphide mineralization. To one familiar with many of the gold lodes in the States, the almost entire lack of iron stains on the quartz and the absence of any undecomposed sulphides in the rocks is very noticeable. It seems, therefore, that the gold must occur in the quartz mainly in a native state rather than mechanically mixed with pyrite or other metallic compounds. If this is true it has an important bearing on the successful search for gold lodes in the district, for the prospector, instead of being able to approximate the value of a ledge by sight alone, must have recourse to competent assays to determine the gold content. It is known that much of the quartz which is said to run $10 to $14 a ton in gold looks like a hard, dense, unmineralized rock which would generally be passed by as "bull quartz." The lode prospector should be advised to sample carefully all strong quartz leads and have the samples accurately assayed, rather than simply to neglect the lead because it looks lean and unlike the auriferous quartz found in many known productive camps. By no means would he always be repaid for his trouble, for undoubtedly many of the leads are barren, but he might discover lodes that would be overlooked in the more crude prospecting. In a quartz lode of low tenor, where the gold is in finely disseminated particles, it would be practically impossible to gain reliable information from roughly crushing the ore and panning.

The main developments at the Big Hurrah mine have been by means of an incline shaft which has a general though not constant slope of about 60°. The strike of the veins is northwesterly and the dip is to the southwest. The upper portion of the vein has also been worked in part by adits run in from the outcropping of the vein on Little Hurrah Creek. North of the main lead there is another vein which occurs about 50 feet below in the foot wall. This vein, unlike the two farther south, has a northwesterly dip, although the strike is essentially the same as the others. It is the belief of the mine operators that this northern vein is a continuation of one of the others, the structure being therefore anticlinal. From the evidence of the structure as shown in the rocks of the neighborhood, as well as from the amount and character of deformation of the veins, it is suggested that such an interpretation is not the correct one, but further developments alone can definitely determine the true structure.

The ore as a rule is in bunches of quartz some of which show a considerable segregation of gold, but the best grade of ore is in what is called locally "ribbon rock." The ribbon character is due to bands of quartz separated from each other by small partings or horses of dark graphitic schist, of varying width but all relatively narrow. The ore breaks down rather readily, as both the hanging and foot walls are generally determined by fault planes which show slickensiding. The faults, however, do not continue uninterruptedly throughout the mine. The movement was along a number of fault planes which were essentially parallel. The time of mineralization seems to have been later than the main folding and deformation of the region but earlier than the slight faulting which is marked by the dislocations already noted. It may therefore be associated with the later stage of mountain building which gave rise to the east-west structural trend now visible in the Kigluaik and Bendeleben mountains.

The Big Hurrah mine is well equipped for carrying on all the necessary mining and concentration processes. The main hoisting plant has consisted of steam-power hoists but the use of oil or gasoline in the future is contemplated, as the efficiency in ratio to the expense is higher. There is a compressor capable of running a few drills, but most of the ore is stoped by hand work. After arriving at the collar of the shaft the ore is trammed by hand through a covered way somewhat over a hundred yards in length to the stamp mill, where it is stored until needed. The stamp mill consists of four batteries of five stamps each. The location is well chosen for economically conducting the various processes, as the level of the track from the shaft is well toward the top of the mill. The batteries are of the usual California type, with automatic feed. After crushing, the ore passes over plates and the major part of the gold is won in the upper few feet. The pulp passing over the plates is led to tables for concentration. Two of the tables are of the Frue type, but the other two are of local construction. The tailings from the tables are carried out to a settling pond formed by diking a flat below the stamp mill. After the plates have been cleaned the amalgam and heavy concentrates from the stamps are put into an amalgamating barrel and slowly rotated with steel balls for twelve hours and then retorted and sold to the bank. The concentrates from the tables are sacked and shipped to outside smelters for treatment. The force employed for both the mine and the mill is about forty men.

In the belt of black graphitic quartzitic schist already noted as occurring in the Solomon and Casadepaga regions there is widespread evidence of mineralization, though save in the immediate neighborhood of the Big Hurrah mine no considerable prospecting has been done. At the small, dry gulch leading from Uncle Sam Mountain there is a prospect pit which has been abandoned for some time. It is sunk on the black quartzitic schist, which is very much sheared and folded; in fact, many of the small quartz veins form a complete S. The quartz of the veins has a peculiar appearance, owing to the presence of a halo of milky crushed quartz around a central more glassy portion. Some of the quartz is heavily iron stained, but as a rule no sulphide minerals are evident. Even on top of Uncle Sam Mountain prospectors have been looking for veins, for there are two abandoned pits slightly to the west of the highest point. In these holes a somewhat mineralized black slaty schist intersected by numerous quartz veins is exposed.

In the lower portion of Linda Vista Creek, a tributary of Big Hurrah Creek, there is a vertical quartz vein which strikes toward the northwest. It is 7 or 8 feet wide and has been faulted twice. Much of the rock near it is considerably crushed. The main evidences of metallic mineralization consist in the large number of limonite stains which cover the quartz. Somewhat north of this vein there is another hole in which an 18-inch quartz vein is exposed. This vein strikes in the same direction as the other, but dips only about 60° SW.

About a mile north of the mouth of Little Hurrah Creek a good deal of prospecting has been done in the past, although work has now been entirely abandoned and the pits are filled with water. This property also occurs in the area of black quartzitic schists, which here strike northwest and dip at a low angle to the northeast. Two inclines with a slope of about 30° have been driven, but the character of the veins could not be determined, owing to the water. Near the inclines there has been about 300 feet of open cutting, but in the exposed area only narrow quartz veins which pinch out within a short distance are visible. The quartz, like so much of the quartz in the black quartzitic slate area, shows but sparing amounts of metallic minerals. Evidences of faulting are common.

On the first tributary to Solomon River from the west below East Fork an adit has been driven on a vein occurring in the black graphitic slates. This vein is located along a fault which has an indeterminate throw, and is distinctly later than the fault. The amount of mineralization is not very great, although in places the rocks are considerably iron stained. The adit is only 20 feet long and the mineralization becomes progressively less toward the breast, and the amount of drag indicated by the wall rocks also diminishes. No work has been done at this place for some time.

Mineralization is also commonly associated with the contact of the limestone and the schists. In many places this mineralization consists only of the introduction of quartz, but in some places sulphides have also been formed. The heavy limestones of the Solomon and Casadepaga regions form a belt along almost the entire western margin of the quadrangles;[a] thence, with some dislocation, swing eastward to form the group of hills of which Mount Dixon is the highest point; and thence, continuing still farther east, form the bare limestone ridges so prominent in the No Man Creek region. There are, however, many other places where limestones occur and in some of these more isolated limestone areas the contacts with the schist show mineralization. At Spruce Creek, near the contact of a much folded limestone and schist, some work has been done in the past on veins which are reported to carry values in free gold. No recent prospecting has been done at this place. On the north side of the divide at the head of Trilby Creek, a tributary of Big Hurrah Creek, there is a quartz stringer which seems to strike north and south, but has been only slightly developed.

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[a] As mapped by the Geological Survey.

At some other places the veins apparently occur near the contact of igneous and sedimentary rocks. Thus at the contact of chloritic schists and greenstones on the high hill at the head of Butte Creek the schists are somewhat impregnated with sulphides, most of which are altered to limonite in the surface exposures. Also at the junction of French Creek and East Fork there is a heavy float of vein quartz showing a small amount of metallic sulphides. Some of the quartz fragments are 3 feet in longer dimension and the float can be traced almost continuously for nearly a quarter of a mile. This locality is near the contact of a limestone and greenstone, where there has been some dislocation.

Still other veins occur in the chloritic schist areas away from any contacts with other rocks. Such a series of veins has been opened on West Creek 2 miles above the mouth. Some work is done here every year and there are 600 or 700 feet of underground workings, but the mine has not yet shipped any ore. The development has been on a north-south vein, which was opened by an adit that drifted along the vein for over 350 feet. In this drift both walls were decomposed chloritic schist which in places showed marked slickensiding. Another adit about 300 feet long has been driven on a vein farther west which shows the same general character as the first. A crosscut following a small cross stringer has been run from the eastern drift. The quartz from all the veins is practically the same in character. It is white and somewhat shattered, but is apparently not sheared nor folded and presumably belongs to the later set of veins. In addition to the quartz the veins carry abundant chlorite and a small amount of pyrite and marcasite. The later metallic minerals occur in small stringers and vugs. The wall rocks are also said to be gold bearing and the foot-wall schist is reported to carry from $8 to $10 a ton in gold, but no assays of the rock have been made by the Survey.

OTHER DISTRICTS.

Near Bluff there has been a more considerable development of a group of properties, with the aim of definitely determining the character and distribution of the ore, than at any other place in the southern and eastern parts of Seward Peninsula. Although this group of claims was not visited during the past year by any member of the Survey, the statements here made are regarded as reliable. In occurrence the ore seems to be closely associated with a limestone-schist contact, with the limestone lying definitely above the schist. In these veins quartz is the most important gangue mineral. The lodes are all located rather near the sea, so that the question of freightage is not serious and supplies can be obtained much more economically than in the camps farther inland. Although these leads have been known for five or six years, the last summer has been more productive of economic results than any previous year. At one claim a shaft about 50 feet deep has been sunk and a short drift about 15 feet in length has been turned off. On the adjoining claim the zone of the mineralization is so wide that two shafts, one on the hanging wall and one on the foot wall, have been sunk. One of these is reported to be 100 feet deep; the other is slightly less than half that length. On the next claim also two shafts have been sunk to a depth of approximately 50 feet. Two shorter shafts have been put down on the next claim, and one shaft about 75 feet deep has been sunk near the end line of the next claim beyond.

The ore from these properties is crushed in an arrastre which is operated by a horse, but it is intended to erect a stamp mill later. No just estimate of the production from this group could be obtained. The properties are particularly interesting as suggesting a possible origin of the gold which has made certain of the creek and beach gravels near Bluff so rich.

Farther east, in the neighborhood of Golofnin, a lode which is reported to give assay returns of $2 to $17 a ton in gold has been discovered, but details regarding the occurrence are wanting.

In the neighborhood of Council several veins were mentioned by the writer[a] in 1907 as having been located and as appearing promising for further exploration. No mining has been done during the last season on the lode southeast of Post Creek other than the annual assessment work. Nor has any development work been carried on near the head of Camp Creek, where another vein was reported last year. The lode near the head of Crooked Creek was prospected to some extent during the winter of 1906–7, but the excavations showed the vein to be constantly decreasing in size until it finally pinched out. Fortunately, however, a hillside placer, formed undoubtedly from the disintegration of this vein, was found farther downhill, so that the owners have more than made up for the loss of the lode.

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[a] Smith, P. S., Gold fields of the Solomon and Niukluk river basins: Bull. U. S. Geol. Survey No. 314, 1907, p. 155.

COPPER.

NOME AND GRAND CENTRAL REGIONS.

At the present time there are only two localities within the Nome and Grand Central regions where lodes carrying copper are being prospected. One of these lodes, on Dexter Creek, is valuable mainly for its gold content, although it is reported that assays showing as much as 4 per cent of copper have been obtained. The second prospect is the larger and is being more actively explored. This lead occurs near the head of Nome River on the high ridge between Copper and Dickens[a] creeks, at an elevation of about 1,250 feet. The deposit is developed by a vertical shaft 10 feet deep and an incline shaft on a low slope was driven on the ore. It was intended to keep three men working on the property continuously during the winter and in this way to systematically explore the ground.

The geologic structure of the area immediately adjacent to the mine is somewhat complex. A narrow belt of heavy white limestone occurs at this place and it is in this limestone that the shaft has been sunk and the veins have been found. Below the limestone on the west there are several shallow prospect pits that show schist fragments and outcrops. The schists exposed under the limestone are of two types; one is a silvery-gray schist with an abundance of small muscovite flakes and much chlorite, the bulk of the rock being quartz; the other is a dark-greenish schist with numerous crystals of feldspar and with some amphibole. It has not been possible as yet to examine these rocks microscopically; but from the evidence acquired by the study of many rocks of nearly identical appearance from near-by areas, it is believed that the silvery schist is of sedimentary origin and that the green schist is derived from an igneous rock. Such an igneous rock would probably be akin to the greenstones, which in Seward Peninsula are allied to the quartz diorites.

Above the limestone there is a strongly developed ledge of typical greenish feldspathic schist which is presumably of igneous origin. The direction of the cleavage, the most dominant structure in the feldspathic schist, is N. 30° W., which is the general trend of the ridge. The dip of all the rocks is northeasterly and as a rule is rather flat. The presence of schists of supposed igneous origin, however, suggests that they may cut the sedimentary rocks and so cause complications in the development of the property. It has been determined in other portions of the Grand Central region that the greenstones are later than any of the sedimentary schists; if, therefore, the feldspathic schists have been derived from these greenstones, they must be the latest hard rocks in the district.

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[a] This creek has recently been given the name Dome Creek by the miners of the vicinity. This seems undesirable, for the creek was originally known as Dickens Creek, claims were staked in this name, and the name was published by the Geological Survey in 1900. It is also undesirable because there are at present five Dome Creeks in Seward Peninsula—one a tributary to Tisuk River, one to American River, one to Taylor Creek, one to Kiwalik River, and one forming part of Iron Creek.

The character of the vein and the distribution of the metals in it are peculiar. All over the surface are numerous blocks of limestone stained with a little malachite, but in the upper portion the vein shows mainly galena. Specimens from this upper portion show numerous drusy cavities and the appearance is that of a replaced limestone. In every fragment several small quartz veins are visible. The ore is almost entirely galena with only a small amount of copper carbonate and practically no copper sulphide. An assay of picked specimens made by the owners is reported to have yielded 15 per cent of copper and 20 per cent of lead, with a rather high silver and low gold content.

In the breast there seems to be a nearly vertical fissure which shows for some distance in the inclined shaft. From this fissure a good deal of bornite, practically unmixed with any other minerals except galena, has been won. This vein seems to pinch out 2 feet or so below the roof and the bornite is absent from the rest of the underground workings. Near the floor of the incline there is a quartzitic rock which looks much like a replaced limestone. This quartzite contains a band about 8 inches thick of copper sulphides and carbonates mixed with quartz. The sulphides are mainly chalcopyrite, and both the carbonates, azurite and malachite, are present. In addition to the main stringers already described, some ore is scattered throughout the breast, but it is too disseminated to allow profitable extraction.

The sulphides in the lower part of the mineralized belt occur nearly parallel with the stratification of the limestone. Nowhere in the underground workings was schist seen, but from the evidence already cited it seeems probable that the contact of the schist would be found a short distance below the floor of the incline. If this is the case and if the underlying schist is igneous in origin, the variation in the ore away from the contact might be explained. It is difficult, however, to believe that the ore was brought in by the igneous action which was responsible for the formation of the feldspathic schists, for the latter, where seen, were not mineralized. Unless, therefore, the distribution of ore may be explained by assuming that the limestone acted as a precipitant for the ore-bearing solutions or gases, while the schist did not, the absence of mineralization in the feldspathic schists is a vital objection to the theory.

About a mile north of the shaft is an exposure of a granite intrusive. Although it is possible that this rock may have had some effect on the deposition of the ore, none of the granite is found near the mine and it is believed that it has no intimate connection with the ore. In the absence of extensive openings that would permit careful study of the details it is believed that the ore was introduced later than the igneous activity connected with the greenstone-feldspathic schist intrusion and was coincident with the replacement of the limestone by silica.

A third of a mile above the mouth of Copper Creek, near the limestone-schist contact, an adit has been run in for 20 or 25 feet on some stringers of copper ore. Work at this point has been abandoned. This property belongs to the same company that owns the prospect on the hill above, and it is believed by the owners that the veins in the two places are the same; but the ground has not been studied in sufficient detail to make such a correlation more than a surmise. Both these properties are favorably located for shipping ore and receiving supplies, as they are less than a mile from the railroad. Already 5 or 6 tons of roughly sorted ore have been shipped for mill tests, but the returns are not yet available.

IRON CREEK REGION.

Between Iron Creek and the broad flat drained by tributaries of the Kruzgamepa and of the Niukluk there is a ridge of heavy white limestone underlain by chloritic and feldspathic schists. From the scattered evidence collected in a hurried examination, it appears that the limestone is very considerably folded but that the major structure is nearly flat. The limestone would appear to be a continuation of the limestone already described as forming the western margin of the Solomon and Casadepaga quadrangles. In those areas the contact with the underlying schist seems to have been a zone of mineralization. In general the mineralization is sparsely disseminated, but in places there are stringers of ore which tempt prospecting.

The greatest amount of prospecting for copper in this contact zone has been at the headwaters of Sherrette Creek, a tributary of the Kruzgamepa. At one place about 4 miles east of the mouth of Iron Creek an inclined shaft has been sunk on a mineralized zone 5 feet in width. The foot wall is a silvery-gray chloritic schist destitute of feldspars. The hanging wall is ill defined, and the width of the ore would have to be drawn on a commercial basis. The foot wall is so poorly exposed that its character may be due to alterations effected by the mineralizing solutions, but it is believed that it is not a schist derived from an igneous rock.

The ore so far disclosed consists chiefly of malachite, but there are also some copper sulphides, mainly chalcopyrite with only a subordinate amount of bornite. The stringers are very narrow and no commercial ore has yet been discovered. All over the hill, however, may be found fragments showing copper stains. This has given rise to the popular belief that the belt of mineralization is very wide. If, however, the interpretation that the ore occurs near the schist-limestone contact is correct and if this contact forms a more or less flat surface, with local wrinklings here and there, it seems more likely that the width of the mineralized area is not very great and therefore that the chance of finding valuable lodes is not promising except in those places where the mineralization, instead of being disseminated over a large area, has been more restricted.

All the float or ledges on the higher ground north of Iron Creek which show copper carbonate stains carry that mineral in the form of malachite. Lower down the slopes, near the upper branches of Left Fork, a tributary of Iron Creek, there is a copper lead where malachite is almost wanting and where the copper carbonate occurs in the form of azurite. The reason for this difference in character is not known. At this place only a small amount of exploration has been done and the ore so far developed is not found in commercial quantities.

OTHER COPPER PROSPECTS.

In the Solomon and Casadepaga regions, as has already been pointed out (p. 237), there is generally some mineralization near the contact of the heavy limestone and the underlying schists. The greatest amount of copper-stained float is found near this contact on Mount Dixon and in the Moonlight Creek divide. At the latter place a shallow prospect pit has been sunk and the larger stringers staked, but on Mount Dixon no exploration has been done. Near the gold prospect west of Spruce Creek, described on page 238, there is also an interesting group of quartz veins showing some copper stains. These veins occur near the contact of limestone and schist at an elevation of about 700 feet. At the contact is found a siliceous rock looking like a replaced limestone. This is cut by nearly unmetamorphosed quartz veins which show finely terminated quartz crystals. These late veins show but slight traces of mineralization other than the quartz; the copper sulphide and carbonates occur in the lower quartzitic layer.

In the Kougarok region a few copper properties have been located. Moffit[a] describes one of these as follows:

> It is located near the head of South Fork of Serpentine River, between Quartz and Bismarck creeks. The copper occurs as carbonates, chiefly malachite with some azurite, with quartz, at a contact of limestone overlying gray mica schist. A shaft 25 feet deep has been sunk above the vein, which dips to the northwest. * * * An incline 20 feet long was also driven in the vein, whose thickness is said to be from 6 to 21 inches, and 10 to 12 tons of ore were taken out.

This prospect has not been visited recently by any members of the Survey. It is not yet on a producing basis. Near the mouth of Taylor Creek, also in the Kougarok district, a copper lode has been reported. The information concerning it is meager, but from some hand specimens which were seen it appears to occur in a much metamorphosed limestone. The copper is disseminated through this rock and occurs mainly in the form of sulphides. The specimens do not indicate a vein of any continuity, but development work has uncovered only the surficial portions.

East of the Kougarok no copper lodes are reported between the river and the vicinity of Mount Bendeleben, where there is a lead concerning which any authentic information is wanting. Still farther east, on the upper branches of Koyuk River, a copper lode has been staked and a small amount of development work was done in the fall of 1906 and the spring of 1907. The hanging wall is reported to be a heavy white limestone and the foot wall a dark-greenish feldspathic schist and greenstone. Although the lode is reported to be very wide, the similarity to the leads that have been studied by members of the Survey in other parts of Seward Peninsula suggests that the zone of mineralization may be flat lying and thus give the appearance of greater width than it really has. Assays made on picked specimens show that there is a high percentage of silver in the ore; thus a return of 17.5 ounces of silver was obtained from ore running 3.4 per cent of copper. The gold content is very low. The location of the lode is unfavorable, for it is very difficult of access and this will undoubtedly hamper developments.

ANTIMONY PROSPECTS.

In 1905 a vein of stibnite was located by float on the divide west of Manila Creek, and some work was carried on in 1906. The condition at this place at the close of 1906 has been described by Moffit.[b] Since that time there has been a fairly steady development of the property. The main work accomplished has been the driving of a crosscut adit which successfully located the vein. This adit was 315 feet long and the vein where intersected was 3 feet wide. It is reported, however, that the amount of antimony was materially less than in the surface exposures, but that the gold tenor had fortunately increased. The quartz is described as being white and compact, with but a small amount of metallic minerals visible. Now it is proposed to erect a stamp mill near the mine and to recover the gold values on the plates. The residue from the stamp will be concentrated on tables; but it is not intended to market the antimony ore at present. Transportation of concentrates from the mine to the smelter at Tacoma costs about $12.50 per ton, and this high rate has led the owners to hold the concentrates in reserve until they feel justified in erecting a plant of their own to treat the antimony. In the present depressed state of the antimony market such a charge for transportation would be a serious handicap to the successful operation of the property. If the decrease in the amount of antimony present in the ore is as marked in the next lower level as it has been from the surface to the adit level the value of the mine is likely to be determined by the gold content of the ore, with very subordinate values in antimony.

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[a] Moffit F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 139.

[b] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, p. 139.

The Manila Creek property is the only one in the district that has shipped any antimony ore, but there are several places in the same general region where stibnite has been found. On the east side of Nome River, near the head of the Osborn Creek drainage basin, three prospectors at the close of the season found promising indications of an antimony lode. The lead is reported to be rather flat lying and is much contorted, the ore occurring in lenses and kidneys. A piece of ore 6 inches wide, 8 inches thick, and a foot long from this vein was examined and found to consist of almost pure stibnite. The ore, in addition to antimony, carries more or less gold. Near the gold lode on Goldbottom Creek also some auriferous antimony ore has been reported, but the prospect was not visited by members of the Survey. On Last Chance Creek a vein which is said to be 5 feet wide has been discovered, but exploration has not proceeded far enough to show the value of the property. Picked samples, however, are reported to yield high assays in both gold and antimony. Near the mouth of Goldbottom Creek on Snake River some stibnite has been found and it was proposed to ship some of the ore, but it is not known whether this was done or not.

GALENA PROSPECTS.

In Seward Peninsula the greatest deposits of galena so far reported are in the region north of Port Clarence and in the hills east of the Fish River basin. The Port Clarence region is described by Knopf on pages 268–271 of this volume. Not much additional information over that published by Mendenhall [a] in 1901 is at hand regarding the region east of Fish River. It is known, however, that during the past year mining and exploration were more actively pursued in the Omalik country than previously. The ore body at this place has been opened up by a shaft, and a crosscut adit has also been driven to connect with the shaft in depth. The ore occurs in a massive, coarsely crystalline limestone. The property is said to have an efficient equipment for development work, but is hampered by the high cost of labor and of transporting supplies.

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[a] Mendenhall, W. C., Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900, a special publication of the U. S. Geol. Survey, 1901, pp. 213–214.

A third locality for galena, near the mouth of Iron Creek on Kruzgamepa River, was brought to the attention of the Survey in the fall of 1907. Three pits have been sunk on the southern side of the river. The easternmost one shows schist very much decomposed and somewhat out of place, with bowlders of yellowish-brown iron-stained limestone above. Twenty-five paces west of this pit there are a series of angular greenstone blocks which seem to be nearly in place and are probably frost-riven fragments from a ledge occupying essentially the position of the greenstone float. A second pit nearer the mouth of Iron Creek shows some galena with a few copper stains. No productive ore is exposed. The third hole, which is nearest the mouth of Iron Creek, is driven in limestone, and there is no schist exposed. In the cut was a lenticular body of galena about 4 feet thick. Most of this has been mined out, but no ore has been shipped. The strike of the limestone in the pit is N. 35° W. and the dip is rather steep to the northeast.

Across the Kruzgamepa and directly opposite these pits is another vein, openings on which show lenses of high-grade galena. This pit is in limestone, but apparently cutting across the bedding of the limestone is a band of feldspathic schist. The galena does not seem to conform to the general strike and dip of the limestone, but the rocks are considerably decomposed and only the surface has been exposed in the excavations, so that accurate determination of the structural features was not possible. The structure is very complex, for within a distance of less than 150 paces the dip of the rocks changes twice from easterly to westerly. It seems clear, however, that the galena at this place occurs as a replacement deposit in limestone near the contact between a schist derived from an igneous rock and a limestone. Owing to the nearness of the exposures on the opposite sides of the Kruzgamepa, it is suggested that the deposits on the south side may be of similar origin. If this is so the decomposed schist lying under the limestone may have been derived from an igneous rock, and the greenstone float noted between the first and second pits on the south side of the river may be in place and the equivalent of the more sheared feldspathic schists which on the north side are observed cutting the limestone. It should be noted that in addition to the galena there is also a little chalcopyrite scattered through the ore.

LODE DEPOSITS OF THE RARER METALS.

BISMUTH.

Near the fork of Charley Creek, a tributary of Sinuk River, bismuth-bearing quartz has been known for some time and was recently described by Moffit.[a] This lode occurs near a limestone-schist contact. During the last season work has been carried on to some extent and the property is being developed by a tunnel. Bismuth is also reported in the Kigluaik Mountains, but no details of the location or occurrence were obtainable.

MERCURY.

Although no well-authenticated find of mercury ores in place has been made in Seward Peninsula, the following quotation from Moffit[b] suggests that the presence of cinnabar is not improbable:

> An interesting fact in connection with the melting of Daniels Creek gold is its loss of weight due to the volatilization of cinnabar caught in the sluice boxes with the gold. The cinnabar occurs in the creek gravels.

MOLYBDENUM.

A small amount of molybdenum, unfortunately not in economic quantities, is reported by Moffit[c] as associated with gold in quartz veins on the divide between Anvil and Glacier creeks. These veins carrying molybdenum occur near the contact of limestones and schists.

TUNGSTEN.

Although no lodes of tungsten have been discovered in Seward Peninsula outside of the area described by Knopf (see p. 262), the presence of much placer scheelite, a lime tungstate, suggests that lodes may be searched for in other portions of the peninsula with some assurance of success. Placer-gold miners in the central part of the Snake River basin often find a considerable amount of scheelite in the concentrates from the sluice boxes. It is a whitish, nonmetallic-looking mineral particularly characterized by its very high specific gravity. It is found only in small quantities and is used in making filaments for certain kinds of electric lights and in the manufacture of very tough steel. The value fluctuates within wide limits owing to the varying conditions of the market, but it may be approximately placed between $400 and $800 a ton.

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[a] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, p. 138.

[b] Moffit, F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 139.

[c] Moffit, F. H., Hess, F. L., and Smith, P. S., Geology of the Nome and Grand Central quadrangles, Alaska: Bull. U. S. Geol. Survey (in preparation).

Float scheelite has also been reported in the Council district, but in amounts so small that the promise of locating the ledges from which it was derived is remote. In the Solomon region, especially near West Creek, a heavy nonmetallic-looking mineral was reported, but the material from this locality examined by the writer proved to be barite. This is also a heavy white mineral, but not of any considerable economic value.

HINTS TO MINERS.

In closing this portion of the report, a general word of advice concerning methods of work may not be unacceptable to those unfamiliar with lode mining. It has been noticed that in many places after an ore stringer has been located on a hillside, there has been a disposition to leave the vein and to start a crosscut adit at a lower level to intersect the ore body in depth. Such a scheme seems too hazardous and too expensive to be attempted in a region where the general character of the veins is no better known than it is in Seward Peninsula. If the vein is caught in the adit all is well and good and the crosscut undoubtedly gives an easy and economical method of handling the ore above that level. But the intersection of the vein in the crosscut is more or less problematical, especially in a region of disturbed rocks. To intersect a vertical vein by means of a crosscut 500 feet below the outcrop where the slope of the surface is 30° requires 850 feet of dead work which gives but meager information concerning the value of the property. On the other hand, if a system of sinking on the vein itself were adopted, an incline or shaft 100 feet in depth would not only block out considerable ore, but would afford much information concerning the character of the vein. Such a system of "gophering" might have to be entirely abandoned for the subsequent economical development of hoisting and breaking down the ore. It would have, however, the advantage of practically doing away with dead work, and would undoubtedly prove the true value of the mine better than a more elaborate scheme based on the assumption that the work done was of permanent character. If the ore body proves to be of value the miner can afford to neglect in large measure the early charges for prospecting, whereas if the surface showings do not continue or if the vein becomes impoverished in depth the sooner he realizes the fact the better.

For the present, therefore, it is believed advisable for the developments to follow the ore even though it may lead in tortuous courses. Such a plan should be pursued until the values of the prospects have been firmly established and the course and character of the veins accurately determined.

NONMETALLIFEROUS PRODUCTS.

Earlier in this paper it has been pointed out that the high cost of essentials has prevented the development of all save the richest deposits, or those which produce an easily converted commodity. For this reason the nonmetalliferous deposits have received but scanty attention. It is true that so important a resource as water has been well utilized. Not only is it developed for mechanical purposes, but even the springs which afford drinking water have been commercially controlled for local use.

FUELS.

Owing to the absence of all forests near many of the most productive camps, the question of fuel is of the highest importance. Lignitic coal has been reported in several places on Seward Peninsula, but in only one of these is it produced on a commercial basis. This mine, near the junction of Chicago Creek and the Kugruk, has been described by Moffit.[a] It is still producing coal and is undoubtedly a great boon to the prospectors in the Inmachuk-Kiwalik country. The coal, however, is not of so good a quality as that from Washington and British Columbia, but the greatly reduced transportation charges make it locally important. For shipments to regions more than a few score miles from the mine, however, the low heat-giving capacity and the high cost of transportation will not permit competition with the Wellington and other outside coals.

Coal is also known in the Sinuk Valley, but the area of the coal rocks can not be over a square mile [b] and the coal is of a poor quality. In the eastern part of the peninsula prospectors report considerable float of lignitic coal on the headwaters of the Tubutulik, but the ledge has not been opened up. Concerning this region Mendenhall [c] says: "No direct evidence of the presence of this mineral [coal] was secured on the Koyuk, but along the river bank, associated with the sandstone [Tertiary?] outcrops, on the Tubutulik, are numbers of small pieces of bright, compact coal, seemingly of good quality." All the coal so far found in Seward Peninsula is lignite, and there is slight probability that other kinds of higher grade will be discovered.

An attempt has been made near Nome to use for fuel the peat and vegetable material which forms the upper 6 to 12 inches of the tundra. The experiment as yet has not been sufficiently thorough to determine its value. It is probable, however, that the peat is too full of rock material and ice to be valuable except in the more inaccessible regions. In special areas, where the peat has accumulated without the admixture of much foreign material, it may be of local importance to prospectors. The long period required to dry the peat and its low fuel value will always be drawbacks to its extensive use.

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[a] Moffit, F. H., The Fairhaven gold placers, Seward Peninsula: Bull. U. S. Geol. Survey No. 247, 1905, p. 67.

[b] Collier, A. J., MS. notes.

[c] Mendenhall, W. C., Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900, a special publication of the U. S. Geol. Survey, 1901, p. 214.

GRAPHITE.

On the southern face of the Kigluaik Mountains the presence of graphite has been known for some time. The occurrence is interesting, for, as has been pointed out by Moffit,[a] there are three distinctly different associations of this mineral. Aside from the scientific interest attaching to this locality, it is of no present importance. On the north side of the mountains, however, not far from Imuruk Basin (locally called Salt Lake), there is another occurrence of graphite which has been recently exploited. At this place a series of very graphitic layers is interlaminated with more quartzose schists. Much of the graphite is obtained in blocks 2 feet in length and a foot in thickness, practically unmixed with foreign material. It is claimed that with rough hand sorting a very high grade ore can be obtained from the group of claims. The owners have already transported several tons of the ore to tide water and expect to ship it for sale in the States. The price of graphite is usually about 4 cents a pound, although there is considerable fluctuation, as the market is small. It would be well, however, to sample the properties on a thoroughly commercial basis before calculating the value, for much of even the high-grade Ceylon graphite contains 10 to 15 per cent of impurities.

MICA.

Mica is another of the nonmetalliferous products that has invited some attention in this region. In the Kigluaik and Bendeleben mountains there are a series of granite and pegmatite dikes which cut the later basic intrusives of the Kigluaik group. As is characteristic of many pegmatites from other parts of the world, the crystals of the component minerals are extremely large. Under such conditions some of the micas are large enough to have commercial value. At the present time the only place in Seward Peninsula where mica has been exploited is in the Bendeleben Mountains. Specimens of the product from this place show that the mica is of light color and that from selected pieces plates 5 or 6 inches square could be obtained. The inability to utilize the by-products and the high cost of mining and transportation will prevent the development of the properties in the near future.

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[a] Moffit, F. H., The Nome region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 139–140.

THE SEWARD PENINSULA TIN DEPOSITS.

By Adolph Knopf.

INTRODUCTION.

The known Alaskan tin deposits that are of a character sufficiently encouraging to warrant prospecting are limited to the extreme western part of Seward Peninsula, and are embraced in an area of about 400 square miles. Four localities are at present being prospected. These are Ear Mountain, Buck Creek, Cape Mountain, and Lost River, named in order from north to south. Ear Mountain is isolated from the other three localities, which are grouped together in what is known as the York region.

The York tin deposits were examined by Collier in 1903[a] and 1904,[b] and by Hess in 1905.[c] No member of the Geological Survey visited the region in 1906. Numerous reports indicated that extensive development work was in progress. Owing to this fact and to the fact that the earlier examinations had been limited on account of lack of time, it was deemed advisable to make a more detailed investigation of the tin deposits in 1907. With this purpose in view the writer was instructed to examine all known occurrences of tin in Seward Peninsula and to give special attention to the origin of the ores and the commercial importance of the field. A summary of results is herewith presented, wherein it is shown that the mode of the origin of the ores has a direct bearing on the economic importance of certain types of tin deposit that are now being prospected. A more detailed report, embracing the scientific results of the investigation, is in course of preparation.

The various localities will be described in geographic order, as already enumerated.

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[a] Collier, A. J., Tin deposits of the York region, Alaska: Bull. U. S. Geol. Survey No. 225, 1904.

[b] Collier A. J., Recent development of Alaskan tin deposits: Bull. U. S. Geol. Survey No. 259, 1905, pp. 120–127.

[c] Hess, F. L., The York tin region: Bull. U. S. Geol. Survey No. 284, 1906, pp. 145–157.

EAR MOUNTAIN.

Ear Mountain is located in the northwestern part of Seward Peninsula, in latitude 66° north, longitude 166° west. It is 50 miles north of Teller and 15 miles south of Shishmaref Inlet. The mountain has long, smooth profiles on the northern and eastern sides, but on the southern and western sides rises abruptly from the tundra-covered plateau which lies at an elevation of 1,000 feet. It is flat topped and attains a maximum elevation of 2,308 feet.

The only cassiterite obtained by the writer from Ear Mountain was stream tin from Eldorado Creek on the northeastern side of the mountain. No tin ore in place could be seen. Attention has lately been directed to some occurrences of yellow copper pyrites and galena along the contact of the granite of Ear Mountain and the rocks that have been intruded by it.

GENERAL GEOLOGY.

The core of Ear Mountain consists of a large intrusive mass of coarse-grained granite. Radiating from this main body of granite are numerous tongues of fine-grained white granite which have been injected into the surrounding sedimentary rocks. These are prevailingly of a limy character, comprising crinkled limestone and lime-mica schists, gashed with numerous quartz stringers. On the south side of the mountain the rocks are more siliceous and include quartzites and black siliceous schists. The youngest rocks of the region are a system of quartz porphyry dikes cutting both the limestones and the granites. The two most prominent of these dikes have a thickness of 15 feet and can be traced for several thousand feet. They strike N. 30° E. and north and south, according to the compass.

The granite of Ear Mountain consists of well-formed feldspars and dark, smoky quartz crystals embedded in a finer matrix of feldspar, quartz, and black mica. The smoky quartz crystals are a characteristic feature of the granite, and have not infrequently been mistaken by the prospector for cassiterite, especially when the color is more intense. In addition to the minerals named, black tourmaline occurs very abundantly. It is, however, usually connected with narrow seams that traverse the granite. These seams consist of quartz and tourmaline and are adjoined by a band of altered granite 2 or 3 inches broad. This alteration has been produced by the introduction of numerous tourmaline needles which have grown at the expense of the earlier-formed feldspar. The quartz-tourmaline seams, on account of their resistance to atmospheric attack, weather out in relief. Several such seams can be seen running up and down the "Ears"—the granite monoliths responsible for the name of the mountain.

The offshoots from the main granite body are finer-grained and lighter-colored granites. They contain, besides quartz and feldspar, white mica and, in many places, numerous small three-sided prisms of tourmaline.

MINERAL OCCURRENCES.

The granite has exerted considerable influence on the sedimentary rocks that surround it, and the line of contact is marked by a belt of rocks of distinct character. Numerous minerals, such as garnet, vesuvianite, and tourmaline, make their appearance in this contact zone. They are due in part to a recrystallization of the material of the sedimentary rocks under the influence of the heat furnished by the granite and in part to an accession of new material by emanations from the granite during its period of cooling. In addition to the tourmaline, axinite, and other contact-metamorphic minerals, the contact rocks are flecked at certain localities with galena, chalcopyrite, and a lustrous coaly black mineral, an iron borate—a mineral new to science and as yet unnamed. It is this type of rock which has raised hopes that copper and lead deposits of economic value exist at Ear Mountain. Tin-bearing rock also is believed by the prospectors to occur along the contacts.

The practical importance of understanding how these deposits were formed arises from the fact that (1) the size and persistence of the deposits and (2) their probable value are dependent on the mode of origin.

Under the first heading attention may be drawn to certain structural features of the granite boss of Ear Mountain—features which occur also at Cape Mountain and at Brooks Mountain. It can be shown from various lines of evidence that any such granite mass as that of Ear Mountain must have cooled under a considerable blanket of protecting rocks. The surface of the granite against these overlying rocks is not necessarily smooth, but may be gently undulating, or may even contain sharp ridges, such as, for instance, have been revealed by the extensive mining operations in Cornwall. The troughs or depressions between these granite ridges will be occupied by the overlying rocks, which will thus appear immersed beneath the general surface of the granite. At Ear Mountain erosion has proceeded far enough to strip off much of the protective capping of sedimentary rocks which formerly arched over the granite, though on the highest peak—the south peak—the granite is still covered under a thickness of 100 feet of schists. (See fig. 5.) This erosion has revealed the fact that the former surface of the granite boss was slightly uneven. The limestones and schists resting in these inequalities now occur as isolated patches surrounded on all sides by granite. The section across Ear Mountain at Eunson's shaft (fig. 6) will illustrate this feature. These rocks may show local indications of ore, but the ore rock, being of contact-metamorphic origin, will have a small areal extent, will have no great depth, and will give out when the underlying surface of the granite is reached. The prospector, therefore, should use considerable caution before attempting any exploitation of ore bodies occurring in such patches of rock lying upon the surface of the granite.

Along the periphery of the granite the ore deposits of contact-metamorphic origin are more likely to have permanence in depth. What is known of contact-metamorphic deposits in other parts of the world, however, is not of a character to encourage extravagant hopes for the similar occurrences found at Ear Mountain. They are usually of low grade and irregular in form. Such deposits are mined in southeastern Alaska for their copper contents, but conditions must be exceptionally favorable to make them of commercial value.

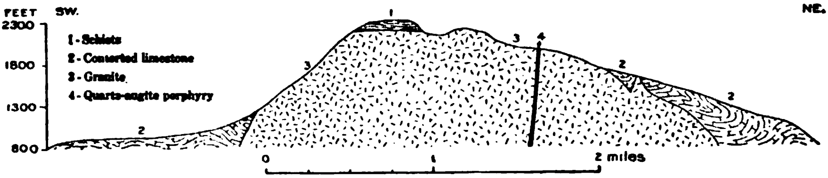

FIG. 5.—Section across Ear Mountain, Seward Peninsula.

On the northeastern side of the mountain, near Vatney's cabin, the contact metamorphism has been more pronounced than usual. Some metamorphosed limestone in proximity to a granite dike was being prospected for tin ore. It contains small bunches of a reddish-brown mineral showing crystal faces, which, when carefully examined, are seen to be diamond shaped. This is typical of garnet. When only the apex of the garnet crystal is visible it bears an exceedingly deceptive resemblance to the four-sided pyramid characteristic of cassiterite.

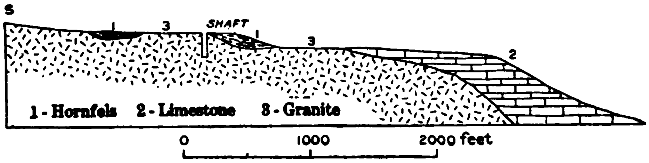

FIG. 6.—Sketch section at Eunson's shaft, Ear Mountain, showing patches of hornfels resting upon granite.

The quartz-tourmaline seams that cut the granite have already been described. At various places on Ear Mountain interlacing networks of such seams occur, and an extensive tourmalinization of the adjoining granite has taken place. Masses of quartz-tourmaline rock have been produced, little resembling the original granite. Such occurrences have been opened up by shallow prospect pits at a number of points. It is quite possible that some deposits of this character may carry low-grade values of tin, but those opened thus far lend small encouragement to this idea. The principal basis of faith, as it exists in the locality, is the presence of abundant tourmaline. It is rather generally held throughout this part of Seward Peninsula that tourmaline is an infallible indication of tin ore. It is true that cassiterite is usually accompanied by tourmaline, but it is emphatically not true that tourmaline is usually accompanied by cassiterite. Tourmaline is of world-wide distribution, and extensive occurrences are known which contain no traces of tin. It would, therefore, appear advisable to proceed cautiously on the tourmaline prospects of Ear Mountain.

The quartz porphyry dikes merit detailed description, inasmuch as they have been actively prospected for tin ore. They consist of dense-textured rock of dark-blue or green color in which are set numerous large crystals of white feldspar and smoky quartz. In addition to these, but occurring in lesser abundance, are augite of a peculiar brownish color and lustrous crystals of black mica. Many of the augites attain unusually large dimensions—as much as 2 inches or more—and are commonly regarded as "tin crystals" by the local prospectors.[a] The presence of these augite crystals, thus mistaken for cassiterite, has led to considerable prospecting of the quartz porphyry dikes. No cassiterite was visible in the specimens submitted to the writer, and he could detect only the minutest grains in the thin sections studied under the microscope. Moreover, chemical analysis of "ore" samples, made in the laboratory of the Survey, showed the presence of traces of tin only, amounting to a few hundredths of 1 per cent.

On the northeast side of Ear Mountain an augite-quartz porphyry dike has been opened by a shaft and explored by a drift 112 feet long. Nothing but hard barren rock was encountered. Work was suspended, and at the time of visit the shaft was flooded with water. Farther southwest, on the extension of the same dike, a number of open cuts have been made on account of the prevalence of numerous large augite crystals embedded in the dike rock.

A shaft known as Eunson's shaft was sunk near the point where a quartz porphyry dike striking north and south crosses the granite-limestone contact. The shaft was reported to be 30 feet deep, but at the time of visit was flooded with water and partly caved in. On the dump a variety of rock is represented. Contact-metamorphosed limestone, granite, granite porphyry, quartz porphyry, and various altered modifications of the quartz porphyry appear. The quartz porphyry is partly tourmalinized and contains small patches of purple fluorite. Arsenopyrite is rather abundant. The tin ore reported from this locality probably came from highly altered portions of the quartz porphyry dike.

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[a] Augite is approximately half as heavy as cassiterite and is easily distinguished from that mineral by the fact that it is rather readily fusible before the blowpipe. Cassiterite is entirely infusible.

BUCK CREEK.

GENERAL GEOLOGY.

The bed rock of the Buck Creek area consists of slates, many of which are poorly fissile and resemble shales. Some greenstones are associated with the slates, but can rarely be found in place. A prominent exposure of greenstone, however, forms a low ridge just north of Buck Creek. The slates dip prevailingly at low angles. The slaty cleavage is developed in an irregular and variable degree in different parts of the area. Much of the rock is shaly looking, but at other points, such as at the head of Sutter Creek, the slates are thinly fissile and the cleavage is at right angles to the sedimentary banding.

Two quartz porphyry dikes cut the slates at the head of Buck Creek. The characteristic feature of these dikes, especially of the one running northward from Potato Mountain, is the number of large, fine glassy quartz crystals set in a light-gray groundmass. The margins of the dikes have been strongly chilled and show a bluish-black rock containing small crystals of quartz and feldspar. Where the dikes are thin they consist entirely of this kind of rock. As is usual in this part of Seward Peninsula, these quartz porphyry dikes have been prospected for tin, and a number of cuts have been opened on them. One of these cuts shows a dike 10 feet wide, somewhat impregnated with pyrite, especially in the vicinity of seams. A small amount of tourmaline in radial groups and a little white mica also appear. Some specimens containing cassiterite have been obtained, but they appear to be of extremely rare occurrence.

The largest porphyry dike, which has a maximum thickness of 50 feet, trends N. 35° W. (magnetic) across the country. It has been faulted approximately 400 feet along the north-south line. The line of this fault is marked by a great quartz vein, 15 feet or more in thickness, which can be traced for considerably more than a mile. The vein contains a vast number of slate fragments, and each of them has acted as a nucleus around which quartz crystals commenced to grow. Failure of the crystals to coalesce in their outer extremities has produced a vuggy vein structure lined with innumerable hexagonal pyramids of quartz. No minerals, with the exception of some botryoidal limonite incrusting the quartz crystals, have been observed in the vein, so that it is without economic importance.

DEVELOPMENTS.

On the ridge of hills at the head of Buck Creek a prospect hole at an altitude of 1,140 feet discloses a fine showing of tin quartz. The claim, known as the "Eureka," is situated on the summit of the ridge. The hole is 10 feet deep, and exposes a face of 7 feet of quartz, carrying a considerable percentage of cassiterite. The quartz is milk white and of greasy luster, and the cassiterite occurs disseminated through it in crystalline aggregates, intimately intergrown with arsenopyrite and small needles of blue tourmaline. Developments on this property are at present inadequate to give either dip or strike of the ore body with any degree of certainty. The depth attained is not great enough to expose solid bed rock. The wall rock is still in a highly shattered condition, due to the heave of the frost. About 60 feet from the prospect hole croppings show that the country rock (slate) is lying nearly horizontal.

At numerous points on the same ridge of hills open cuts have been made exposing networks of quartz stringers in the slates. Some carry cassiterite and some merely show small rosettes of blue tourmaline. At the head of Peluk Creek a shaft 20 feet deep was sunk on stringers in the slate. The quartz on the dump shows abundant pyrite and here and there some cassiterite.

In the vicinity of this last-mentioned occurrence float tin ore has been picked up in which the cassiterite occurs in a totally different mineral association. It is found in a green rock, composed largely of radiating groups of actinolite. Under the microscope some finely granular calcite is found to be associated with the actinolite. Arsenopyrite, in amounts greatly exceeding the cassiterite, is very abundant. A number of open cuts have been made in the effort to locate the bed-rock source of this tin ore. At the time of visit the owner had just succeeded in uncovering the edge of the deposit in place, so that no facts are available as to its probable value. It is apparently lying flat and seems to represent a stratum of limestone interbedded between impervious slates and now highly altered by the action of tin-bearing solutions.

CAPE MOUNTAIN.

Cape Mountain forms the promontory fronting Bering Strait at the westernmost extremity of the American continent. On the eastern flank of the mountain are a few scattered houses, which form the settlement known as "Tin City." Tin City is 110 miles by steamer route from Nome, with which it is now connected by telephone.

GENERAL GEOLOGY.

Cape Mountain consists of a granite mass which has invaded a series of crystalline limestones of Carboniferous age. The limestones are lying nearly flat, but with a slight easterly dip. They extend eastward nearly to the mouth of Baituk Creek, where they are faulted against the York slate of undetermined age. At the cape the limestones dip in toward the granite. Some siliceous schists are associated with the limestones. Their main development is in the capping forming the summit of Cape Mountain, where they are 300 feet thick. Some narrow dikes of basalt cut the granite as exposed in mining operations.

The granite of Cape Mountain is a coarse-grained gray rock, strongly porphyritic, containing numerous large crystals of feldspar. The essential minerals making up the granite are, in addition to the feldspar, quartz and black mica. Along the contact with the limestone the feldspars are aligned with their longer axes parallel. More commonly, however, the granite becomes fine grained along its margin, and fluorite, tourmaline, and white mica appear. A number of dikes, standing nearly vertical, cut the rocks surrounding and overlying the granite. In addition, horizontal sheets of granite have been forced in between the limestone beds. These features tend to increase the irregular character of the contact surface between the limestones and the granite. Some limestone masses were broken off from the roof which covered the granite at the time of its intrusion and partly sank into the molten rock. An isolated limestone patch which had this origin rests in the granite near the head of Lagoon Creek. Attention is drawn to these foundered blocks of limestone, because, if any ore occurs along their contacts, it can have only a meager distribution. The principal effect of the intrusion of the granite on the surrounding limestone has been to coarsen its grain and to produce a coarse white marble, extending at a maximum 200 or 300 feet from the contact. Proximity to the granite contact is indicated in many places by the peculiar rough appearance of the limestone, due to the development of small patches of lime-silicate minerals, ordinarily invisible to the eye. These weather out in relief and give the limestone a characteristic "shaggy" appearance near the granite. Contact metamorphism is relatively rare, and is confined mainly to the limestone adjoining the dikes.

ORE DEPOSITS.

Tin ore occurs in three ways at Cape Mountain—(1) in tourmalinized granite dikes and peripheral portions of the main granite mass; (2) in contact-metamorphic rock; (3) in veins in granite and as an impregnation of the adjoining wall rocks. The miner makes no distinction between the first and second modes of occurrence. In general it may be said that the ore of the first type is apt to be of low grade, and that the second is an unlikely source of tin ore. The third is the normal type of lode tin the world over.

Some of the dikes cutting the limestone show margins which are strongly tourmalinized. Large masses of bluish tourmaline occur, and some of these carry rich bunches or pockets of tin ore. The limestone adjoining the dikes has here and there been converted into coarse white spar in which numerous prisms and columns of tourmaline are embedded. In places it is difficult to discriminate between tourmalinized limestone and tourmalinized dike rock. The tourmalinization, however, appears to be purely local and erratic in occurrence. Furthermore, the tourmaline, though, as already stated, in some places rich in cassiterite, is in general quite barren.

The contact rocks adjoining the main granite mass and some of the granite sills have been prospected at a number of places. A heavy green rock, here and there showing pyrrhotite, has been regarded as tin ore, but microscopic and chemical analysis fail to reveal any tin. The green rock is locally known both as "greenstone" and as "tinstone." It is a finely granular rock consisting of augite and fluorite in equal proportions. This rock is well exposed in a cut on the Canoe claim, where a few feet of it directly overlie a granite sill 8 feet thick. At other points on Cape Mountain, notably half a mile north of the Lucky Queen, the augite is embedded in calcite. The augite, which is unusually well developed for a contact-metamorphic rock, is of brown color and does not look unlike cassiterite. Where tin is suspected in such rocks, assays can give the only reliable information.

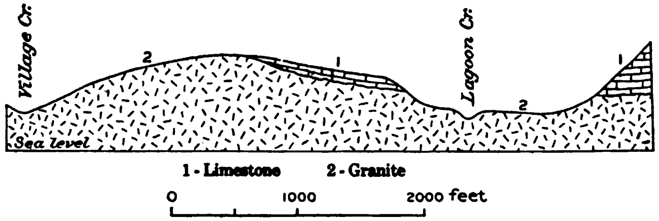

FIG. 7.—Section across Lagoon Creek, Cape Mountain, one-half mile below Canoe claim, showing thin capping of limestone resting in granite.

The statements regarding deposits of contact-metamorphic origin made for the Ear Mountain region are equally applicable to Cape Mountain. (See fig. 7.) In addition, the highly irregular nature of the granite contact makes prospecting for such deposits difficult, and would entail heavy and probably unwarrantable expenses in mining them.

Up to the present time a single narrow quartz vein has been found in place, cutting the granite on the north side of Cape Mountain at an altitude of 1,850 feet. The vein is accompanied by some alteration to greisen and by partial tourmalinization of the adjoining granite—changes characteristic of tin-bearing veins. At other points on Cape Mountain cassiterite accompanied by tourmaline is found as an impregnation of the granite adjoining slips or fault planes. This type of occurrence, in the opinion of the writer, holds out greater possibilities for the future of the district as a tin producer than do the other two. Unfortunately exploratory work has been confined mainly to the contact deposits.

DEVELOPMENTS.

At the time of visit two properties only were being actively worked—those of the United States Alaska Tin Mining Company and the Bartels Tin Mining Company. The former property is situated near the summit on the north side of Cape Mountain. Developments up to the end of July, 1907, consisted of a shaft reported to be 22 feet deep, now filled with water, and a 7-foot tunnel 270 feet long. The company has also erected a 10-stamp mill near the beach at Tin City. Four men were employed at the time of visit. The shaft is sunk upon a quartz ledge 1 foot thick, striking N. 45° W. (magnetic) and dipping 80° E. The tunnel, whose altitude is 1,600 feet according to aneroid, is driven in a direction S. 40° W. through hard, firm granite and is expected to tap the ledge 250 feet below the collar of the shaft.

The main development work by the Bartels Tin Mining Company has been done on the North Star property. Eight men were employed during the summer of 1907. The main tunnel with its drifts and winzes aggregated 750 feet in length. This tunnel is being driven to catch the granite-limestone contact at a depth of 100 feet below the workings of the Lucky Queen tunnel. About 400 feet from the mouth of the tunnel a band of granite was encountered carrying numerous visible crystals of cassiterite, associated with some tourmaline. The width of this band is about 18 inches. The granite is soft and iron stained. The succeeding 3 feet consists of gray hard granite carrying pyrite disseminated through it. This is followed by 15 feet of iron-stained granite. At the time of visit the 18-inch belt of rich tin ore had not been drifted on to prove its persistence. The drifts branching off from the main adit follow the contact of a large limestone block which was evidently torn off from the main limestone mass during the intrusion of the granite. In following this contact, which proved to be of a highly irregular nature, several winzes were necessary.

A new tunnel, 67 feet below the North Star tunnel, is being run from the surface to connect with the lowest drifts reached by these winzes. The granite along the limestone contact is charged with numerous radiating groups of tourmaline prisms, with iron oxide, and locally with pyrite and tin ore. Some crushing has taken place along the contact, and heavily iron-stained gouge matter, a foot in thickness, has been produced. At points where the red clayey material is absent the granite is fresh and the progressive increase of fineness of grain as the contact is approached can be noted.

A considerable portion of the energies of the company has been expended on assessment work on the numerous claims which it holds on Cape Mountain.

LOST RIVER.

Lost River is a small stream rising near Brooks Mountain in the northwestern part of Seward Peninsula and flowing southward into Bering Sea. The tin prospects of this region are located 6 miles from the coast on Cassiterite Creek, a branch of the river.

GENERAL GEOLOGY.

The bed rock of the Lost River region is prevailingly limestone, known as the Port Clarence limestone, which has been determined on fossil evidence to be of Silurian age. The Port Clarence limestone dips to the north at an angle of about 20°, and in this region has a thickness of not less than 2,000 feet. Two types of rock can readily be distinguished. One consists of a dark leaden-gray limestone forming massive beds. It breaks into large blocks and on fracture appears somewhat crystalline. The other is ashy gray in color and is of dense texture, like lithographic stone. It breaks readily into large thin slabs and many of these are covered with fragments of fossil seaweeds. Some shale is locally associated with the limestone. Near the head of Cassiterite Creek the limestone is intimately banded with shale and intensely crumpled.

On Tin Creek, another tributary of Lost River, a small granite boss a third of a mile in diameter is intruded into the limestone. Its principal effect has been to convert the surrounding limestone into a white marble, though locally some large masses of contact-metamorphic minerals have been formed, consisting chiefly of brown garnet and vesuvianite. A considerable number of quartz porphyry dikes pierce the limestone. They are fairly persistent and can be traced for several miles across the country. The quartz porphyries are light-colored rocks containing small glassy quartz crystals embedded in a matrix irresolvable by the naked eye. The main tin prospects of the region occur in highly altered dikes of this character. The various other dikes have all received separate names and have been more or less prospected, on what encouragement, however, the writer is unable to understand. They are usually unmineralized, except for sporadic cubes of pyrite, and there is no known reason why they should become tin bearing with depth.

CASSITERITE PROSPECTS.

At Tin Creek some thin quartz-cassiterite stringers have been found in the granite. Collier has shown that some pyritiferous granite from the same locality contains 0.3 per cent of tin. A cut has been opened on this occurrence and shows a number of narrow bands of altered granite carrying finely divided pyrite and arsenopyrite.

The principal tin prospects are located on Cassiterite Creek and occur in the quartz porphyry dike known as the Cassiterite lode. This dike is 6 to 10 feet thick and can be traced from the head of Tin Creek in a northwesterly direction over to Lost River, a distance of 9,000 feet. The conspicuous features of the dike rock are its white color and the numerous fine crystals of quartz embedded in it. The quartz porphyry dike has broken through an older dike, a feldspar porphyry, along a portion of its course.

The tin-bearing portion of the dike has a maximum length of 3,000 feet. This portion is marked by a large amount of alteration, a highly varied mineralization, and an intense seaming of the adjacent limestone with innumerable veinlets. The tin ore contains cassiterite and wolframite, associated with iron oxide, pyrite and arsenopyrite, some molybdenite, and rarely a little galena and sphalerite. The gangue material consists of kaolin, quartz, fluorite, zinnwaldite, topaz, and calcite, though all are not present together. The richest tin ore is associated with quartz and lithia mica seams an inch or so in thickness, cutting the quartz porphyry. Considerable alteration has taken place in the rock adjoining the seams, and cassiterite occurs as an impregnation in belts parallel to the stringers. Wolframite is constantly associated with the cassiterite, and though no actual tests have been made, it is probable that the tungsten content of the lode is as valuable as the tin. Where no such seams occur the quartz porphyry is hard and barren and contains no cassiterite. The dike is intensely and irregularly slickensided. Clay gouge is common and the whole mass of rock is stained red with iron oxide. The limestone wall rock, however, is firm and hard. It is considerably impregnated with fluorite, which glows with a greenish light when struck with the pick. No cassiterite appears in the wall rock.

A few hundred feet north of the Cassiterite lode is another quartz porphyry dike, known as the Ida Bell lode. It is about 35 feet thick on the summit of the hill between Lost River and Cassiterite Creek. The rock is dense and fine grained. In the vicinity of Cassiterite Creek stringers of quartz and cassiterite with some wolframite, an inch or so in thickness, cut the porphyry dike. The alteration that is so characteristic a feature of the Cassiterite lode is conspicuously absent from the Ida Bell quartz porphyry dike.

At the time of visit five tunnels had been driven on the Cassiterite lode, three of which were open and could be examined. Tunnel B, 260 feet above Cassiterite Creek, was 180 feet long. The tunnel follows the southern margin of the dike and is partly in limestone. At 45 feet from the mouth a drift has been run 10 feet to the north, crosscutting the lode. Tunnel A 1, 170 feet above the creek, was 80 feet long. The dike rock is soft and can be augered, so that an advance of 4 feet per day (single shift) is easily made. Both these tunnels are on the east side of Cassiterite Creek. On the west side is Tunnel E, 100 feet long. A 9-foot crosscut has been driven 50 feet from the mouth of this tunnel. From the foregoing statements it is apparent that developments are substantially the same as recorded by Hess[a] for 1905.

One mile north of the Cassiterite lode is another tin-bearing quartz porphyry dike which has been named the Dolcoath lode. It is from 2½ to 3 feet thick, strikes N. 50° E. (magnetic), and dips 65° NW. This dike differs considerably from the two previously described, both in its mineralogy and in the mode of occurrence of the tin ore. It is so highly altered that its original quartz porphyry character is not readily apparent. Some movement has taken place along the walls of the dike, especially on the hanging wall, forming a crush zone 1 to 6 inches thick. The dike rock is heavily charged with arsenical pyrites and tourmaline and contains some cassiterite disseminated through it. The limestone wall rock has been converted into coarse white spar, much of which contains numerous small white prisms of tremolite. Cassiterite occurs embedded in this spar, and is locally somewhat rich. These bands of wall rock carrying tin ore, occurring on both foot and hanging walls, are nowhere more than 6 inches thick. Cassiterite also occurs in the wall rock intimately intergrown with pocket-like masses of danburite, which is a borosilicate related to topaz. The Dolcoath dike has been opened by four cuts, of which the extremes are 3,000 feet apart. An assay of ore from one of the crosscuts was reported to have yielded 1.15 per cent of tin.

A highly interesting mineral deposit, occurring opposite the mouth of Tin Creek, on the ridge between Lost River and Left Fork, was shown to the writer as a galena prospect. As pointed out at the time, however, wolframite is probably the most valuable part of the deposit and the presence of tungsten has subsequently been verified in the chemical laboratory of the Survey. In addition to the wolframite, considerable galena is present. Much of it is intercrystallized with a brown-black mineral which gives reactions for tin, copper, zinc, iron, and sulphur, and has been identified as stannite. This is the only known occurrence of stannite in the Alaskan tin region. These various minerals occur embedded in a gangue of topaz, with some deep-purple fluorite. The topaz is crystallized in fine radial aggregates, a few of them half an inch in diameter. The high specific gravity of topaz (3.5) accounts for the unusual weight of the ore. Assays are claimed to show also returns in silver.[a] The surface ore is stained black by manganese derived from the decomposition of the wolframite. Some azurite is also present and is doubtless derived from the copper in the stannite. Little has been done to prove this property. The surface indications show that the mineralization has taken place along a fault zone, running east and west, which has been brecciated and recemented. An open cut shows stringers of ore occurring in a belt 1 foot thick, forming a stringer lode.

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[a] Bull. U. S. Geol. Survey No. 284, 1906, pp. 146-150.

Stannite is not a valuable ore of tin. Its occurrence in amounts sufficient to form an ore is extremely rare. In only one place in recent years has it been found in such amounts—at the Oonah mine in Tasmania, where an argentiferous stannite is associated with pyrite and chalcopyrite. Here it was mined for silver and copper, and the tin was rejected as waste product. Arrangements were finally made with the smelter that for ore containing at least 8 per cent of tin $5 per ton should be paid in addition to the ordinary returns for silver and copper.[b] Wolframite, which occurs associated with both the cassiterite and stannite of the Lost River region, is valuable for its tungsten content. Wolframite is a tungstate of iron and manganese, the pure mineral containing 76 per cent of tungstic trioxide (WO_3). Tungsten ores which are used for steel hardening are paid for on the basis of their percentage of tungstic trioxide, the present price being about $10 per unit. Ores concentrated up to 60 or 70 per cent would therefore have a value of $600 to $700 per ton. Wolframite is distinguished by its high specific gravity, perfect cleavage, black color, and brilliant submetallic luster on its cleavage faces. It is softer than cassiterite and can be scratched with the knife. In the Lost River region the iron-rich zinc blende of Brooks Mountain resembles wolframite in color and luster, but differs in the fact that its cleavage faces show six different directions, whereas in wolframite all cleavage faces are strictly parallel. In the absence of chemical tests this is the only means of distinction between the two minerals.

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[a] Since this paper was written returns from an assay made by Ledoux & Co., of New York, on a sample submitted by the Survey show 22.9 ounces of silver per ton.

[b] Waller, G. A., Report on the Zeehan silver-lead mining field, Govt. Geol. Office, Tasmania, 1904.

PLACERS.

BUCK CREEK.

Developments subsequent to 1905 have revealed few new facts of interest in regard to the placers of Buck Creek. The gravels have a length of about 4 miles and are of shallow depth. Work below the mouth of Sutter Creek has shown that the gravel is from 120 to 160 feet wide, averaging about 125 feet. A pit averaging 5 feet in depth has shown that the gravel may run as high as 25 pounds of concentrates per cubic yard. The richest gravel rests immediately upon bed rock and is exceedingly clayey and toughly bound together. It gives difficulty in washing, the clay having a tendency to roll up in balls and carry cassiterite nuggets over the sluice boxes. The bed rock is a broken shale or slate that is very clayey but contains no cassiterite. On Sutter Creek, the large southern branch of Buck Creek, there is a considerable body of gravel, and the discovery of stream tin has recently been reported. The other tributaries, gulches, and "benches" of Buck Creek contain little or no gravel, at least in amounts sufficient to warrant any considerable outlay for the purposes of placer mining.

The stream tin of Buck Creek is clearly derived from the erosion and concentration of the cassiterite occurring in the quartz stringers so abundant throughout the area. This source was partly supplemented by the cassiterite occurring in the actinolite rock, and to lesser extent by that contained in the quartz porphyry dikes. As these bed-rock sources are known to occur in place on the summit of the hills, at the head of Buck Creek, it is probable that the creeks flowing into Lopp Lagoon carry stream tin. But whether cassiterite is present in paying quantities is purely a matter of accurate sampling and not of opinion or theory.

Two companies were in operation on Buck Creek during the last season, but on account of the number of adverse circumstances the output was less than anticipated. Placer mining was confined to a small strip just below the mouth of Sutter Creek. The production for the season was approximately 50 tons.

At the beginning of the season the American Tin Mining Company was working its ground by means of an automatic scraper and belt conveyor operated by a 35-horsepower oil-burning engine. Early in August, however, extortionate freight rates on the transportation of crude oil from Nome to York and the imperfect adaptation of the scraper to the character of the gravel necessitated a change in the method of working. Shoveling in was then resorted to, with results at least more satisfactory than those attained with machinery.

GROUSE CREEK.

Assessment work was done on a number of claims on Grouse Creek and two of its tributaries, Sterling and Skookum creeks. The results are not known. Some gold sifted out of the concentrates from Sterling Creek was flat and coarse, not greatly waterworn, and with quartz still adhering to it.

FAIRHAVEN DISTRICT.

A sample of black-sand concentrate sent in for determination from Humboldt Creek proved to be a very rich tin ore, containing less than $5 per ton in gold. About two-thirds of the sample was pyrite. Another sample sent in from Kougarok River was found to contain considerable cassiterite, but far less than that from Humboldt Creek. It contained, however, 85 ounces of gold per ton. The sample was two-thirds pyrite and contained about 10 per cent of magnetite. As the headwaters of Humboldt Creek drain the Hot Springs granite area, the tin was probably derived from that region. Collier states that samples of tin ore purporting to come from it were brought to Nome late in the season of 1902.

RÉSUMÉ AND CONCLUSIONS.

The Alaskan lode tin deposits are associated with granitic intrusives. The ore occurs in a variety of ways:

(1) In highly altered quartz porphyry dikes.
(2) In tourmalinized margins of granite masses and granitic dikes.
(3) In contact metamorphic deposits.
(4) In quartz stringers cutting slates and limestones.
(5) In quartz veins cutting granite and accompanied by impregnation of the adjoining granite.
(6) In beds of actinolite rock interstratified with slates.

Inasmuch as the granite intrusives have in many places profoundly modified the sedimentary rocks surrounding and enveloping them, with the production of numerous unusual and heavy minerals, it has happened that the contact-metamorphic deposits have received the most attention. This tendency to regard the contacts as favorable ore horizons has been strengthened partly by the fact that some rich masses of tin ore have been found near tourmalinized limestone, and partly by the deceptive resemblance which the heavy contact minerals, such as garnet, bear to cassiterite. The chances of finding workable tin mines in deposits of this type are, however, extremely slight. Quartz porphyry dikes, locally known as lodes or even as quartz veins, have received considerable attention owing to the fact that the original discovery of lode tin in Alaska was made on a highly altered dike of this character. The unwelcome fact should be speedily realized that few of these dikes hold out any inducements whatever as prospective tin producers. Of the other types of occurrence, some of which are of promising character, it can be said that, from the point of view of the conservative mining man, their value remains yet to be proved.

Developments throughout the region are for the most part still in the prospecting stage. Many of the open cuts have not reached solid bed rock. No tonnage of ore, with one exception on Lost River, has yet been blocked out. It follows, then, that, on account of inadequate development, no data are available for a safe estimate of the future commercial importance of the Alaska tin deposits. The region is plainly not "a poor man's country," but appears, however, to offer a limited field for cautious exploration by capital.

The placer deposits, and those from a single stream only—Buck Creek—have so far supplied the bulk of the Alaskan tin.

THE MINERAL DEPOSITS OF THE LOST RIVER AND BROOKS MOUNTAIN REGION, SEWARD PENINSULA.

By ADOLPH KNOPF.

INTRODUCTION.

Lost River is a small stream rising in the heart of the York Mountains, in the western part of Seward Peninsula. It flows southward into Bering Sea and has a total length of 9 miles. Its valley is broad and open and furnishes a good wagon roadway. The region is destitute of vegetation, even the arctic mosses being scarce. The general geologic features are described in the preceding paper. The Lost River region displays a varied mineralization, and prospecting has disclosed, in addition to the tin deposits previously described, occurrences of silver-lead, tungsten-lead, copper, and perhaps gold deposits.

ALASKA CHIEF PROPERTY.

The Alaska Chief is situated 4½ miles from Bering Sea on Rapid River, the large western branch of Lost River. The workings are located on a small gulch tributary to Rapid River. The country rock in the vicinity of this property is a tough, fine-grained limestone, lying nearly horizontal. Locally the strata are buckled and show crushing in the crests of the buckles. A fault breccia, 15 feet wide, consisting of small angular fragments of limestone cemented together by white calc-spar, is exposed in the creek one-third of a mile west of the mine. Basalt, in the form of a narrow dike 1 foot thick, is the only other rock known to be in place in the near vicinity. A few thousand feet to the east a number of quartz porphyry dikes can be seen cutting the limestone.

The original shaft was sunk on a heavy body of porous red iron oxide containing galena, reported to be 12 feet thick. At a depth of 35 feet work was suspended. An adit, 143 feet long, driven 85 feet below the collar of the shaft, encountered the same ore body 50 feet below the bottom of the shaft. The ore was still oxidized. About 7 feet of low-grade galena ore was exposed.

On the east side of the gulch a devious tunnel, about 600 feet in length, was driven to catch another body of galena indicated on the surface. The tunnel follows a zone of crushed limestone, in many places bounded by fine walls marked with striæ. The " ledge matter " consists of small fragments of limestone bound together by coarse calc-spar, clay, and red iron oxide. No ore was encountered. The tunnel on the west side of the gulch was then commenced, and the ore body already mentioned was struck late in August, 1907.

IDAHO CLAIM.

A few yards below the mouth of Tin Creek a copper prospect has been opened on the edge of the 15-foot bench fronting Lost River. Enough work had been done to expose the face of ore at this point. The deposit occurs in an irregular shatter zone in the limestone, 15 feet wide, and includes numerous horses of unmineralized limestone. The ore mineral is chalcopyrite, associated with abundant pyrrhotite (magnetic iron pyrites), and occurs in a gangue of calcite, fluorite, and small fragments of slickensided rock. Some of the fluorite is rose tinted and is locally known as ruby quartz. Stripping has shown that the same ore body extends at least 50 feet to the east, where a strong gossan has been uncovered. The relatively great width of the deposit, combined with the low chalcopyrite tenor and the large amount of pyrrhotite present, reduces the copper percentage to a small figure.

TIN CREEK.

On Tin Creek a galena prospect has been opened up on some gossan croppings at an altitude of 1,100 feet, or 800 feet above the bed of the creek. The deposit occurs in a fracture zone in the limestone, which has been coarsely recrystallized in the immediate vicinity, forming spar crystals up to an inch in size. The gossan consists of honeycombed masses of iron oxide containing abundant galena and numerous white and colorless crystals of cerusite (lead carbonate). It was planned to prove the value of this deposit during the winter of 1907.

A small trench, 650 feet below the galena prospect, has been dug in the effort to locate the bed-rock source of some loose bowlders composed of arsenopyrite flecked with a small amount of cupriferous pyrite. Assays made in Nome are reported to have yielded $12 to the ton in gold.

On the divide at the head of Tin Creek stibnite associated with a deep-purple fluorite was found by a member of the Survey party.

BROOKS MOUNTAIN.

Brooks Mountain is the dominant peak of the York Mountains, and lies in the watershed of the Bering and Arctic drainages. It is easily accessible from the coast by way of Lost River, a distance of 9 miles. The mineral deposits of Brooks Mountain are all of contact-metamorphic origin.

A large granite mass, 2 miles long by two-thirds of a mile wide, forms the southern flank of the mountain. The rocks surrounding the granite are chiefly limestones, excessively crumpled over much of the region. The granite is characterized by the presence of numerous large crystals of feldspar, commonly an inch in diameter, and large crystals of smoky quartz exceeding peas in size. Through the body of the rock are scattered many small flakes of black mica. Along the margin of the granite mass the granite has been strongly tourmalinized, and large masses of black tourmaline are of common occurrence. Theoretically, it might be expected that such a granite would have exerted a considerable influence on the surrounding rocks. This expectation is completely realized. A great variety of contact-metamorphic minerals have been produced, among which a green or brown-green vesuvianite is the most abundant. Much of the vesuvianite occurs in beautiful crystals embraced in a matrix of white spar, and the interesting discovery has been made that it contains boron, the element characteristic of tourmaline. Among the other minerals produced in the rocks adjoining the granite are garnet, magnetite, argentiferous galena, a brilliant black sphalerite, pyrrhotite, pyrite, arsenopyrite, fluorite, mica, tourmaline, a coal-black iron borate (as at Ear Mountain), a magnesian iron borate, and a fibrous green borate resembling ludwigite. This array of minerals, consisting of numerous species foreign to the prospector's acquaintance and of relatively high specific gravity, has naturally excited some attention, and a number of prospects have been opened on these contact-metamorphic deposits. It seems desirable to repeat the cautions given in connection with the similar types occurring on Ear Mountain. Contact-metamorphic deposits are, as a rule, characterized by extreme irregularity of form; they can not persist into the granite; furthermore, such deposits as occur in small masses of limestone, resting upon or embedded in the granite, can have only a very small extent. It is therefore advisable to consider carefully the geologic surroundings of even the most promising surface indications.

At the west end of the Brooks Mountain granite mass a prospect trench discloses a body of argentiferous galena ore. The deposit occurs 20 feet from the granite contact, in a coarsely crystalline white limestone. The strike of the ore body, as revealed in the open cut, is N. 15° W. (magnetic) and the dip 65° toward the granite. A body of solid ore 3½ feet thick is exposed. The galena is strongly mixed with lustrous black zinc blende. Some pyrrhotite is also present, but is comparatively rare. Where any gangue mineral is visible, it consists of fluorite. The ore body is frozen to both walls. The hanging wall shows a belt of finely granular fluorite several inches thick, succeeded by extremely coarse calcite containing a few crystals of diopside and some galena. The grain of the calcite decreases away from the ore body.

In the vicinity of the galena prospect contact-metamorphic rocks are found containing vesuvianite and a fibrous green boron mineral intercrystallized with galena. It is clear that the galena ore, with its unusual mineral associations, is of contact-metamorphic origin. Assays made in Nome yielded 34 per cent of lead and 11 ounces of silver per ton. Other assays were reported to give an ore value of $17 and $44 per ton.

In the same general locality some contact masses of vesuvianite have been prospected for nickel. The vesuvianite is finely granular and gives the rock a general green color. This feature and the unusual weight of the rock (that is, compared with quartz) are doubtless responsible for the nickel prospecting. No indications of nickel are present, and it may be added that such a mode of occurrence for nickel is totally unknown.

In the canyon below the galena claim some assessment work has been done on a showing of contact-metamorphic minerals. This deposit is interesting from a scientific standpoint, inasmuch as a hitherto unknown boron mineral has been discovered in it, but nothing of commercial importance has been found here. The minerals comprise brown garnet, much of it showing rhombic faces, green or yellowish-green vesuvianite, and abundant magnetite closely associated with the new mineral—a black mineral showing a fine cleavage and a bright submetallic luster. These various minerals are all included in a matrix of coarse white spar.

At the head of the same canyon some more contact-metamorphic deposits have received attention. Here, at an altitude of 2,000 feet, a small prospect hole exposes a mass of metamorphic minerals occurring in a white marble a few feet from the granite contact. Tourmaline, fluorite, calcite, pyrite, arsenopyrite, and brilliant black sphalerite (an iron-rich zinc blende) occur confusedly intergrown. The ore body is 4 feet thick and penetrates the marmorized limestone in irregular tongues. Some galena was noted in the ends of these tongues. The value of this deposit is problematic. A few hundred feet farther north the limestone has undergone an intense contact metamorphism. The resulting product consists of vesuvianite, calcite, and garnet interspersed with minute flakes of mica (phlogopite). Some of this rock contains sphalerite and other sulphurets, which on oxidizing give it a gossan appearance. High gold assays were claimed from this type of rock. Ledoux & Co., of New York, report on an assay sample submitted by the Survey: Gold, trace; silver, 0.23 ounce.

On the north side of Brooks Mountain, at an altitude of 1,850 feet, is located a small galena prospect. The galena occurs in a gossan, the skeleton of which consists of tourmaline. The iron oxide of the gossan contains lead and bismuth.

WATER SUPPLY OF THE NOME AND KOUGAROK REGIONS, SEWARD PENINSULA, 1906-7.

By Fred F. Henshaw.

INTRODUCTION.

The operation of the gold placers in Seward Peninsula had by 1906 reached such a stage of development that its future success was largely dependent on the possibility of mining large bodies of relatively low-grade gravel. The most common method of working such ground has been by hydraulicking. For this method a large and steady supply of water under a high head is a necessity. To obtain such a supply a large number of ditches have been built, many of them long and constructed at great expense. There was little exact information as to the available water supply, and many of these hydraulic works have been failures owing to insufficiency of water. Most of these failures could have been averted had reliable data been at hand in regard to stream flow.

For these reasons the United States Geological Survey started systematic measurements of the flow of streams in Seward Peninsula in 1906.[a] Owing to the smallness of the funds available, the work was confined to the southern portion, and especially to the streams from which water could have been taken for working the rich placers near Nome, as shown on the Nome and Grand Central topographic sheets. In 1907 the work in this district was continued and the investigations were extended into the Kougarok region, north of the Kigluaik Mountains.

These investigations consisted in (*a*) determining both the total flow and the distribution of the flow of various streams during the mining season; (*b*) collecting facts in regard to general conditions affecting water supply; (*c*) gathering statistics in regard to the diversion and use of water.

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[a] Hoyt, J. C., and Henshaw, F. F., Water supply of Nome region, Seward Peninsula, 1906: Water-Sup. and Irr. Paper No. 196, U. S. Geol. Survey, 1907; Bull. U. S. Geol. Survey No. 314, 1907, pp. 182–186.

MEASUREMENTS.

Discharge measurements were made at 45 points in 1906 and at 42 in the Nome region and 32 in the Kougarok in 1907. The detailed results of these measurements are given in Water-Supply Paper No. 218, from which the following summaries are taken. Table 1 shows the monthly discharge at stations where daily discharges could be computed. Table 2 gives the minimum flow of streams rising in the foothills, in the mountains, and in the Kougarok region. The results are in second-feet. To reduce to miner's inches of 1.5 cubic feet per minute, multiply by 40; for miner's inches of 1.2 cubic feet per minute, multiply by 50.

Table 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7.*

STREAMS RISING IN FOOTHILLS.

NUGGET CREEK AT MIOCENE INTAKE.

[Drainage area, 2.1 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 9–31	12.0	3.8	5.7	2.71	2.32
August	10.6	2.8	6.2	2.95	3.40
September	40	6.8	11.0	5.24	5.85
84 days	40	2.8	7.8	3.71	11.57

JETT AND COPPER CREEKS (COMBINED).

[Drainage area, 2.25 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	40	5.9	17.3	7.69	8.87
August	15	3.9	7.1	3.16	3.64
September	49	2.9	9.6	4.27	4.76
92 days	49	2.9	11.3	5.04	17.27

DAVID CREEK AT MIOCENE INTAKE.

[Drainage area, 4.3 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	76	10.9	32.2	7.49	8.64
August	30	8.9	14.2	3.30	3.80
September	107	8.3	20.7	4.81	5.37
92 days	107	8.3	22.4	5.20	17.81

HOBSON CREEK AT MIOCENE INTAKE.

[Drainage area, 2.6 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
June 28–30	26.7	25.0	25.8	9.92	1.11
July	25.8	19.6	22.6	8.69	10.02
August	20.4	14.3	17.1	6.58	7.59
September	22.3	16.5	19.1	7.38	8.20
95 days	26.7	14.3	19.8	7.62	26.92

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—**Cont'd.**

STREAMS RISING IN FOOTHILLS—Continued.

SNAKE RIVER ABOVE GLACIER CREEK.

[Drainage area, 69 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
June 25-30	540	258	401	5.81	1.30
July	308	120	177	2.56	2.95
August	135	77	108	1.56	1.80
September 1-15	540	111	207	3.00	1.67
83 days	540	77	173	2.51	7.72

PENNY RIVER AT SUTTON INTAKE.

[Drainage area, 19 square miles.]

1907.					
July	181	55	78.7	4.14	4.77
August	88	33	59.0	3.11	3.58
September	175	45	71.1	3.74	4.17
92 days	181	33	69.6	3.66	12.52

STREAMS RISING IN KIGLUAIK MOUNTAINS.

NORTH FORK OF GRAND CENTRAL RIVER AT THE FORKS.

[Drainage area, 6.9 square miles.]

1907.					
July 8-31	80	32	48.7	7.06	6.30
August	152	27	58.1	8.42	9.71
September 1-23	238	21	64.7	9.38	8.02
78 days	238	21	57.2	8.29	24.03

NORTH FORK OF GRAND CENTRAL RIVER NEAR DITCH INTAKE.

[Drainage area, 5.4 square miles.]

1906.					
July (17 days)		23	39.9	7.39	4.67
August	71	25	36.7	6.80	7.84
September 1-18		25	31.6	5.85	3.92

NORTH FORK OF GRAND CENTRAL RIVER AT PIPE INTAKE.

[Drainage area, 2.3 square miles.]

1906.					
July 1-4, 20-31	48	21	30.3	13.2	7.86
August	53	19	27.4	11.9	13.7
September 1-18	31	17	22.2	9.65	6.46
65 days		17	26.6	11.6	28.0
1907.					
July 8-31	64	26	39.0	16.9	15.1
August	110	20	43.5	18.9	21.8
September 1-23	171	15	46.5	20.2	17.3
88 days	171	15	43.0	18.7	54.2

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906-7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS—Continued.

WEST FORK OF GRAND CENTRAL RIVER AT THE FORKS.

[Drainage area, 7.7 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 8-31	140	42	84.5	11.0	9.82
August	291	42	81.0	10.5	12.1
September 1-23	406	34	100	13.0	11.1
78 days	406	34	87.8	11.4	33.0

WEST FORK OF GRAND CENTRAL RIVER AT DITCH INTAKE.

[Drainage area, 5.4 square miles.]

1906.					
July 1-5, 10-31	162	22	62.0	11.5	11.5
August	54	21	32.5	6.02	6.94
September 1-18	44	19	25.5	4.72	3.16
76 days	162	19	41.3	7.65	21.6
1907.					
July 8-31	110	28	60.0	11.1	9.90
August	103	35	50.2	9.30	10.7
September 1-23	149	31	50.7	9.39	8.03
78 days	149	28	53.4	9.89	28.6

WEST FORK OF GRAND CENTRAL RIVER AT PIPE INTAKE.

[Drainage area, 2.8 square miles.]

1906.					
July 1-4, 11-31	72	12	27.0	9.64	8.96
August	30	7.6	13.9	4.96	5.72
September	22	6	9.4	3.36	2.25
74 days	72	6	17.2	6.14	16.93
1907.					
July 8-31	48	12	26.4	9.43	8.42
August	52	11	17.6	6.29	7.25
September 1-23	74	10	20.5	7.32	6.26
78 days	74	10	21.2	7.64	21.93

CRATER LAKE OUTLET.

[Drainage area, 1.8 square miles.]

1906.					
July 1-5, 10-31	69	8	22.3	12.4	12.4
August	31	5	11.8	6.56	7.56
September 1-18	13	3.1	5.2	2.89	1.93
76 days	69	3.1	14.0	7.78	21.9
1907.					
July 8-31	40	12	24.4	13.6	12.1
August	52	8	26.0	14.4	16.6
September 1-23	106	3.5	21.0	11.7	10.0
78 days	106	3.5	24.0	13.3	38.7

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS—Continued.

GRAND CENTRAL RIVER BELOW THE FORKS.

[Drainage area, 14.6 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1906.					
July 1-5, 9-31	370	56	144	9.86	10.27
August	210	53	85.2	5.84	6.73
September 1-18	100	47	62.0	4.25	2.84
77 days	370	47	101	6.92	19.84

THOMPSON CREEK.

[Drainage area, 2.5 square miles.]

1906.					
July 1-4, 11-31	52	10	20.5	8.20	7.62
August	40	9	16.6	6.64	7.66
September 1-18	19	5	7.6	3.04	2.10
74 days	52	5	15.7	6.28	17.38
1907.					
July 8-31	87	27	42.2	16.9	15.1
August	50	9	27.0	10.8	12.4
September 1-23	100	5	22.8	9.12	7.80
78 days	100	5	30.4	12.2	35.3

GOLD RUN.

1906.					
July 1-4, 11-31	69	13	29.0		
August	68	15	27.6		
September 1-18	30	10	15.3		
74 days	69	10	25.1		
1907.					
July 8-31	86	18	47.0		
August	90	13	41.1		
September 1 23	120	10	32.1		
78 days	120	10	40.1		

KRUZGAMEPA RIVER AT SALMON LAKE.

[Drainage area, 81 square miles.]

1906.					
May 28-31	3,270	2,180	2,720	33.6	5.00
June 1-7, 23-30	2,520	308	1,160	14.3	8.00
July	2,130	245	571	7.05	8.13
August	475	175	259	3.20	3.69
September	1,455	175	456	5.63	6.28
111 days	3,270	175	610	7.53	31.00
1907.					
June 15-30	2,360	935	1,480	18.3	10.9
July	875	295	548	6.77	7.80
August	555	229	335	4.14	4.77
September	1,560	217	477	5.89	6.57
October 1-5	205	178	187	2.31	.43
113 days	2,360	178	587	7.25	30.47

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS—Continued.

NOME RIVER AT MIOCENE INTAKE.[a]

[Drainage area, 15 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1906.					
July	260	21	51.4	3.43	3.96
August	176	20	50.4	3.36	3.87
September	194	25	64.4	4.29	4.79
92 days	260	20	55.4	3.69	12.61
1907.					
June 15–30	384	124	202	13.5	8.03
July	168	23	72.2	4.81	5.54
August	75	16	32.9	2.19	2.52
September	307	18	58.4	3.89	4.34
108 days	384	16	76.4	5.09	20.43

UPPER SINUK RIVER.

[Drainage area, 6.2 square miles.[b]]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	100	24	52.3	8.44	9.73
August	100	22	45.0	5.49	6.33
September 1–22	160	7	53.7	6.55	5.36
84 days	160	7	50.0	6.86	21.42

NORTH STAR CREEK.

[Drainage area, 2.3 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	30	4	14.8	6.43	7.41
August	25	4	8.3	3.61	4.16
September 1–22	40	2	8.9	3.87	3.16
84 days	40	2	10.9	4.74	14.73

WINDY CREEK.

[Drainage area, 12 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July	140	40	91.5	7.62	8.78
August	125	32	59.2	4.93	5.68
September 1–22	200	15	68.1	5.68	4.65
84 days	200	15	73.4	6.12	19.11

STREAMS IN THE KOUGAROK REGION.

KOUGAROK RIVER AT HOMESTAKE INTAKE.

[Drainage area, 44 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 15–31	29	6.3	12.4	0.28	0.18
August	110	3.2	22.8	.52	.60
September 1–20	351	26	79.1	1.80	1.34
68 days	351	3.2	36.8	.84	2.12

[a] These values are the natural flow of the river and have been found by subtracting the flow of the David Creek, Nugget Creek, and Jett Creek ditches from the actual flow, and adding that of Campion ditch.

[b] 8.2 after August 1.

TABLE 1.—*Monthly discharge of streams in Seward Peninsula, 1906-7*—Cont'd.

STREAMS IN THE KOUGAROK REGION—Continued.

TAYLOR CREEK AT CASCADE INTAKE.

[Drainage area, 74 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 15-31	186	8	29.9	0.40	0.25
August	186	3.9	54.2	.73	.84
September 1-20	441	35	119	1.61	1.20
68 days	441	3.9	67.1	.91	2.29

KOUGAROK RIVER ABOVE COARSE GOLD CREEK.

[Drainage area, 250 square miles.]

Month.	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1907.					
July 14-31	200	33	67.2	0.27	.18
August	490	16	141	.56	.65
September 1-20	1,240	130	388	1.55	1.15
69 days	1,240	16	193	.77	1.98

TABLE 2.—*Minimum daily flow of streams in Seward Peninsula, 1906-7.*

STREAMS RISING IN FOOTHILLS.

Stream.	Elevation.	Drainage area.	1906.			1907.		
			Date.	Minimum flow.	Minimum run-off per square mile.	Date.	Minimum flow.	Minimum run-off per square mile.
	Feet.	*Sq. m.*		*Sec.-ft.*	*Sec.-ft.*		*Sec.-ft.*	*Sec.-ft.*
Iron Creek below mouth of Canyon Creek.	450	50	Aug. 14	17.1	0.34	Aug. 11-14	33	0.66
Eldorado River below mouth of Venetia Creek.	400	51	Aug. 14	44	.86			
Jett Creek	800	1.4	Sept. 10	[a]4.2	3.0	Sept. 23	[b]2.9	1.3
Copper Creek	800	.85	Aug. 11	.8	.94			
Nugget Creek	785	2.1	June 28	[c].96	.46	Aug. 10-11	2.8	1.3
David Creek	590	4.3	Aug. 19	3.3	.77	Sept. 30	8.3	1.9
Dorothy Creek	500	2.7	Aug. 18	2.9	1.1			
Hobson Creek	500	2.6	July 4	10.5	[d]4.0	Aug. 19	14.3	5.5
Slate Creek (tributary to Stewart River).	700	2.1	Aug. 19	2.2	1.05			
Stewart River	400	36	Aug. 19	11.4	.32			
Snake River	40	69				Aug. 12	77	1.1
Penny River	120	19	Aug. 1	[a]36	1.9	Aug. 15	33	1.7

[a] Lowest measurements obtained. The flow was less on certain dates.

[b] Jett and Copper creeks combined.

[c] The lowest flow later in 1906 was 3.0 second-feet, or 1.4 second-feet per square mile, on August 11.

[d] The flow of Hobson Creek is from large limestone springs whose catchment area may not coincide with the surface watershed.

TABLE 2.—*Minimum daily flow of streams in Seward Peninsula, 1906–7*—Cont'd.

STREAMS RISING IN KIGLUAIK MOUNTAINS.

Stream.	Elevation.	Drainage area.	1906.			1907.		
			Date.	Minimum flow.	Minimum run-off per square mile.	Date.	Minimum flow.	Minimum run-off per square mile.
	Feet.	*Sq. m.*		*Sec.-ft.*	*Sec.-ft.*		*Sec.-ft.*	*Sec.-ft.*
North Fork of Grand Central River near ditch intake.	750	5.4	July 1	23	4.3	--------	--------	--------
West Fork of Grand Central River at ditch intake.	850	5.4	Sept. 15-17	19	3.5	July 29	28	5.2
Crater Lake outlet	925	1.8	Sept. 15-17	3.1	1.7	Sept. 22-23	3.5	1.9
Thompson Creek	720	2.5	Sept. 16-17	5	2.0	Sept. 22-23	5	2.0
Grand Central River below forks.	600	14.6	Sept. 16-17	47	3.1	Aug. 15	72	4.9
Grand Central River below Nugget Creek.	455	39	Sept. 16-17	90	2.3	--------	--------	--------
Grand Central River between station below the forks and station at Nugget Creek.	--------	24.4	Sept. 16-17	43	1.76	--------	--------	--------
Kruzgamepa River	442	81	Aug. 19 and Sept. 17.	175	2.16	Oct. 5	178	2.2
Crater Creek	550	11	Sept. 16-17	39	3.5	--------	--------	--------
Fox Creek	550	11	Aug. 16	17.3	1.6	--------	--------	--------
Nome River	575	15	Aug. 5	20	1.3	Aug. 15	16	1.1
Buffalo Creek	800	4.4	Aug. 3	9.1	2.1	--------	--------	--------
Sinuk River	770	[b]6.2	Aug. 3	20	3.2	Aug. 15	[a]22	2.7
North Star Creek	900	2.3	Aug. 10	2.9	1.26	Aug. 7	[a]4	1.7
Windy Creek	650	12	Aug. 3	32	2.7	Aug. 15	[a]32	2.7

STREAMS IN THE KOUGAROK REGION.

Stream.	Elevation.	Drainage area.	Date.	Minimum flow.	Minimum run-off per square mile.	Date.	Minimum flow.	Minimum run-off per square mile.
Kougarok River at Homestake intake.	--------	44	--------	--------	--------	Aug. 13	3.2	0.07
Kougarok River above Coarse Gold Creek.	--------	250	--------	--------	--------	Aug. 9-12	16	.06
Taylor Creek at Cascade intake.	--------	74	--------	--------	--------	Aug. 14	3.9	.05
Henry Creek at mouth	--------	50	--------	--------	--------	Aug. 13	6.8	.14
North Fork above Eureka Creek.	--------	66	--------	--------	--------	Aug. 15	9.6	.15
Noxapaga River	--------	340	--------	--------	--------	Aug. 16	62	.18
Turner Creek	--------	13	--------	--------	--------	Aug. 15	.7	.05
Budd Creek	--------	58	--------	--------	--------	Aug. 21	25	.43

[a] Minimum in midseason.

[b] 8.2 after August 1, 1907.

AVAILABLE WATER SUPPLY.

In order to show the water supply available during 1906 and 1907 for the Nome and Kougarok regions the mean flow of streams in each drainage basin has been tabulated by weekly periods. The following table should not be taken as indicating the amount of water that could be used, which will, of course, be limited by the capacity of the ditches that have been or may be built.

The working season of the Miocene ditch was from June 20 to October 13, 1906, and from June 27 to October 3, 1907. The water of Hobson Creek was running in the ditch between these dates. The Nome River water was used from June 26 to October 12, 1906, and from July 3 to October 3, 1907. These dates mark the limit of the period during which water could have been used in any of the ditches of the Nome region. The season for Grand Central and Sinuk rivers would have been at least a week shorter at each end of both years, as the snow lasts longer and the slush ice begins to run earlier at the higher elevations where these streams rise. The working season may begin somewhat earlier in the Kougarok region than it does south of the mountain, as there is a lighter snowfall, and the ditches can be cleaned out earlier. The season closed on September 21, 1906, and September 20, 1907.

Especial attention is called to the small rate of run-off from the streams in the Kougarok region as compared with that of Grand Central, Nome, and Sinuk rivers. This is due to the extremely small rainfall in the northern area, as indicated by the records obtained at Shelton and Taylor. (See p. 282.) This condition is believed to prevail over the entire northern portion of Seward Peninsula. Caution should therefore be used in future hydraulic development in that section, to determine whether the water supply is sufficient.

Mean weekly water supply, in second-feet, available for use back of Nome, 1906–7.

Date.	Available for use at elevation 220 to 280 feet, Nome River low level.	Available for use at elevation 400 to 450 feet.				Total.
		Nome River high level.	Upper Grand Central River, Thompson Creek, and Gold Run.	Nugget, Copper, and Jett creeks.	Sinuk River, Windy and North Star creeks.	
1906.						
July 1-7	43	45	153	7	88	324
July 8-14	155	144	[a]343	26	173	796
July 15-21	52	58	179	15	90	378
July 22-28	43	40	156	12	79	325
July 29-August 4	36	42	101	8	50	223
August 5-11	39	45	108	8	49	236
August 12-18	49	53	91	8	42	228
August 19-25	81	84	138	10	62	352
August 26-September 1	130	128	202	22	94	540
September 2-8	68	73	101	14	51	287
September 9 18	48	53	68	9	36	199
September 19-30	120	118	250	20	125	599
Mean	72	74	158	13	78	375
Maximum	155	144	343	26	173	796
Minimum	36	42	68	7	36	199
1907.						
July 1-7	135	199	([b])	36	152	522
July 8-14	102	152	292	27	172	745
July 15-21	84	107	228	21	143	583
July 22 28	60	77	183	15	105	440
July 29-August 4	44	59	144	11	77	335
August 5-11	36	49	107	8	50	250
August 12-18	49	62	190	13	95	409
August 19-25	47	61	245	15	86	454
August 26-September 1	72	89	318	18	124	621
September 2 8	51	63	142	14	72	342
September 9-15	176	204	418	40	167	1,005
September 16-23	60	76	115	24	62	337
September 24-30	45	56	([b])	15	([b])	116
Mean	74	96	216	20	109	473
Maximum	176	204	418	40	172	1,005
Minimum	36	49	107	8	50	116

[a] Too small; no record of highest water.

[b] No record. No water could have been used from Grand Central River the first week in July on account of snow, nor from either Grand Central or Sinuk rivers the last week in September on account of slush ice.

Mean weekly water supply, in second-feet, of Kougarok River drainage basin, 1907.

Date.	For Dahl Creek at elevation 300 to 350 feet.			For upper Kougarok at elevation 600 to 700 feet.					
	Kougarok River.	North Fork.	Total.	Kougarok River.	Taylor Creek.	Henry Creek.	Coarse Gold Creek.	North Fork.	Total.
July 15-21	57	22	79	14	16	19	12	5.2	66
July 22-28	88	22	110	13	53	14	9.6	3.0	93
July 29-August 4	33	12	45	6.7	7.3	7.3	3.8	1.2	26
August 5-11	21	10	31	5.4	5.0	6.3	3.3	1.0	21
August 12-18	26	13	39	4.5	9.0	5.4	3.9	1.0	24
August 19-25	328	73	401	60	117	28	29	30	264
August 26-September 1	262	83	345	33	117	21	26	27	224
September 2-8	331	76	407	57	100	33	27	21	238
September 9-15	584	117	701	133	181	94	100	44	552
September 16-20	228	45	273	46	68	33	39	17	203
Mean	196	47	243	37.3	67.3	26.1	25.4	15.0	171
Maximum	584	117	701	133	181	94	100	44	552
Minimum	21	10	31	4.5	5.0	5.4	3.3	1.0	21

SUMMARY OF DITCHES IN NOME REGION.

The following table has been prepared to show in a concise manner the flow of the ditches which take their water supply from Nome River and its tributaries, and from near-by streams. It is also of value for comparison with the discharge of the streams from which the water is taken, to show the percentage of flow that can be delivered by a ditch at the point where it is to be used.

Monthly discharge of ditches in Nome region, 1907.

Ditch.	Point of measurement.	Yearly maximum.	July.		August.	September.
		Sec.-feet.	*Days.*	*Sec.-feet.*	*Sec.-feet.*	*Sec.-feet.*
Campion	Black Point	18.0	25	9.0	12.9	12.5
Miocene	Black Point	42.6	29	28.0	34.4	38.7
	Clara Creek	37.0	29	25.4	28.7	33.7
	Above Hobson Creek	34.9	29	23.6	27.4	31.8
	Below Hobson Creek	54.7	31	43.8	45.3	47.9
	Flume	55.2	31	45.1	44.0	50.4
	David Creek branch	16.5	15	11.3	11.8	9.0
	Jett Creek branch	8.2	20	4.9	6.1	[a]6.1
	Grand Central branch	13.4	23	5.7	6.2	9.0
Seward	Nome River intake	29.0	21	23.9	26.2	25.7
	Hobson Creek branch		26	5.2	4.3	4.5
Pioneer	Nome River intake [b]	26.8	16	20.4	22.2	21.8
	Hobson branch					5.8
Sutton	Intake	35.0	31	23.9	23.8	31.8
Cedric	Penstock	17.8	10	12.3	12.9	9.6

[a] Mean for 14 days.

[b] Values for Pioneer ditch have been estimated at 85 per cent of those for Seward ditch; this was the proportion during the time for which records were obtained on both ditches.

RAINFALL.

In connection with the stream gaging, rainfall records were obtained at three stations in 1906 and at six in 1907. Observations of rainfall, precipitation, temperature, and barometric pressure were made during the winter at Nome by Arthur Gibson, C. E.

Monthly rainfall, in inches, at stations on Seward Peninsula, 1906–7.

Station.	Elevation.	June.	July.	August.	September.	Total, June to August.	Total, June to September.	Total, July to September.
1906.	*Feet.*							
Nome	40	Trace.	2.38	2.50	1.02	4.88	5.90	5.90
Salmon Lake	450	Trace.	4.92	3.33	3.28	8.25	11.51	11.51
Ophir	200	Trace.	3.57	1.91	([a])	5.48	----------	----------
1907.								
Nome	40	1.31	2.08	2.68	1.41	----------	7.48	6.17
Black Point	575	2.62	1.94	2.85	3.28	----------	10.67	8.05
Salmon Lake	450	2.31	1.79	3.65	2.26	----------	10.01	7.70
Grand Central	690	([a])	3.61	7.19	5.06	----------	----------	15.86
Shelton	60	([a])	.71	1.33	.47	----------	----------	2.51
Taylor	550	([a])	.66	.96	1.17	----------	----------	2.79

[a] No record.

Monthly summary of weather observations at Nome, December, 1906, to November, 1907.

	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Annual.
Rainfall,[a] inches	1.91	2.64	1.46	3.37	0.10	1.12	1.31	2.08	2.68	1.41	0.16	0.06	18.30
Snowfall, inches	20.8	25.2	13.9	28.8	......	......	......	......	......	......	1.7	1.5	91.9
Temperature (°F.):													
Monthly maximum	29	33	31	33	41	49	65	66	69	52	44	39	69
Monthly minimum	−15	−24	−31	−32	−14	15	30	34	30	29	3	−12	−32
Mean of daily maxima	13.3	19.7	−0.8	14.2	25.9	39.5	52.1	55.9	55.8	46.4	30.0	15.9	30.7
Mean of daily minima	-0.2	4.2	−14.4	−3.1	12.1	29.1	38.9	44.2	43.8	35.7	19.0	3.1	17.7
Mean	6.8	11.9	−7.6	5.6	19.0	34.3	45.5	50.0	49.8	41.1	24.5	9.5	24.2
Mean barometer, inches	30.17	30.24	30.02	30.01	30.01	30.03	29.91	29.88	29.74	29.64	29.74	29.65	29.92
Number of days—													
Clear	16	10	19	11	18	10	12	10	8	13	15	10	152
Partly cloudy	4	4	2	2	2	5	5	4	9	6	3	4	50
Cloudy	11	17	7	18	10	16	13	17	14	11	13	16	163

[a] Including melted snow.

NOTE.—The rainfall for October, 1906, was 0.93 inch, and for November, 1906, 0.32 inch.

The following statement gives briefly the climatic conditions existing in this area during the years 1899–1907:

1899. July, four rainy days; August, fourteen rainy days; September, fourteen rainy days; recorded at Teller.

1900. June and July, warm and dry, tundra fires common; August to end of September, rain.

1901. June to August, inclusive, cold and foggy with some rain; September and October, usually clear and cold with one or two hard rains of a few days' duration.

1902. June, dry; July, ten rainy days; August, six rainy days; September, three rainy days; recorded at Teller.

1903. Summer warm; little rain, but considerable fog.

1904. June, dry; rainy days as follows: Ten in July, ten in August, ten in September; temperature moderate.

1905. Very wet and cold the whole season.

1906. Very warm and dry; tundra fires common; maximum temperature 85°.

1907. A heavy snowfall and a late spring; rainfall not excessive, but water supply of Nome region good on account of its even distribution throughout the season.

HYDRAULIC DEVELOPMENTS IN 1907.

NOME REGION.

Construction work was done on several ditches in the Nome region during 1907, but so far as known no new ones were started.

The Nome River ditch of the Pioneer Mining Company was completed about July 15. Three siphons were required—one across Hobson Creek, 545 feet long, one across Banner Creek, 1,050 feet long, and one across Dexter Creek, 755 feet long.

The Independent ditch on Osborne Creek, which has been described by Moffit,[a] was completed in July and the water was used during about half of the season.

On the developments in upper Grand Central River little work was done, pending a settlement of the question of the ownership of the water rights. The Miocene Ditch Company built somewhat less than a mile of ditch. The Wild Goose Mining and Trading Company put together about a mile of its wood-stave pipe line. No work was done on the power plant at Salmon Lake.

IRON CREEK.

Two ditches were built to work ground on lower Iron Creek. One has its intake below Canyon Creek, and is 2 miles long and 6 feet wide on the bottom. A head of 50 feet is obtained. The other ditch, which was mentioned by Smith,[b] takes its water from Rock, Slate, and Willow creeks, tributaries of Kruzgamepa River, and conveys it over the divide to work ground on Bobs and Iron creeks. The ditch is 8 miles long and 3 feet wide on the bottom, but will probably be enlarged. A head of 350 feet above the bed of Iron Creek is obtained.

KOUGAROK REGION.

Much activity was shown in ditch building in the Kougarok region and in the territory immediately adjoining it. Of the ditches on Kougarok River and its tributaries which have been previously described,[c] those on Henry Creek and North Fork were not used in 1907. Much sodding and other repair work was done on the other four—the Homestake, North Star, Cascade, and Irving ditches—and water was turned into them on different dates in July and August. No ditch operator was able to mine throughout the season, on account of delay in starting and the extreme drought that occurred during the first half of August.

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[a] Moffit, F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, p. 142.

[b] Smith, P. S., Geology and mineral resources of Iron Creek: Bull. U. S. Geol. Survey No. 314, 1907, p. 163.

[c] Moffit, F. H., Gold mining on Seward Peninsula: Bull. U. S. Geol. Survey No. 284, 1906, pp. 143–144. Brooks, A. H., The Kougarok region: Bull. U. S. Geol. Survey No. 314, 1907, pp. 169–170.

A number of other ditches were begun in 1907. The Coarse Gold ditch takes its water from that creek about 5 miles above its mouth, and extends along its south bank to Twobit Gulch, a small tributary of Kougarok River, a distance of between 5 and 6 miles. The ditch is 8 feet wide, but it is planned to widen it and extend it eventually to Dahl Creek. The McKay Hydraulic Mining Company built about 17 miles of 4-foot and 5-foot ditch from Turner Creek to the benches of Noxapaga River near Goose Creek. Most of this ditch was built over ground ice, which caused much trouble by thawing and settling. The Pittsburg-Dick Creek Mining Company finished its ditch on Bryan Creek and began another which will take water from Quartz and Bismarck creeks. The Bryan Creek ditch is 6½ miles long and 6 feet wide, and gives a pressure of about 170 feet at the mouth of Dick Creek, a tributary of Bryan Creek which will be mined.

The Quartz Creek ditch is 8 miles long and 8 feet wide on the bottom. It will discharge into the Bryan Creek ditch, which is about 350 feet lower in elevation, but it is possible to extend it to the head of Dick Creek, a total distance of over 20 miles.

The Budd Creek ditch of the Ottumwa Gold Mining Company has its intake at the large spring on that creek and extends for 8 miles along the north bank to a point below the mouth of Windy Creek, giving a head at the lower end of 160 feet. This waterway is 9 feet wide, and has a grade of 3.7 feet per mile. A second ditch was built by the same company on Million and Ohio creeks, tributaries of Windy Creek.

FAIRHAVEN PRECINCT.

No member of the Geological Survey has visited the Fairhaven district since 1903. The following notes on some of the developments in that section have been compiled from reliable sources. Two of the longest ditches in Seward Peninsula have been built and a third has been begun.

The Fairhaven ditch was built during 1906 and 1907 by the Fairhaven Water Company. It takes its water supply from Imuruk Lake, the source of Kugruk River. A dam about 500 feet long has been constructed across the outlet of the lake to conserve the run-off.

The upper section of the ditch is 17 miles long, the first 8 miles of which is through a lava formation. The water is dropped into upper Pinnell River and flows down this stream for about 4 miles. The lower section takes the water from Pinnell River on its right bank and extends for 23 miles to Arizona Creek, where a head of 500 feet is obtained. The ditch is 11 feet wide on the bottom and has a grade of 5 feet to the mile.

The Candle ditch was built during 1907 by the Candle-Alaska Hydraulic Gold Mining Company to furnish water for mining on

Candle Creek. It has a total length of 33.6 miles, a bottom width of 9 feet, and a grade of 3.69 feet per mile. The estimated capacity is 35 second-feet.

It takes its supply from the western tributaries of Kiwalik River. The present intake of the ditch is on Glacier Creek. The water is carried across Dome Creek in a siphon 2,250 feet long composed of 28-inch pipe; across Bonanza Creek in 900 feet of 32-inch pipe; and across Eldorado Creek in a siphon 12,100 feet long composed of equal lengths of 35½, 37½ and 39½ inch pipe. Eldorado Creek will be tapped with a lateral ditch about 6 miles long. An extension 8.1 miles long of 6-foot ditch will be built to Gold Run. It will also be possible to divert the flow from the headwaters of First Chance Creek a tributary of Koyuk River, over a low divide into Gold Run.

The fall obtained is 250 feet at the mouth of Candle Creek and 132 feet at the mouth of Patterson Creek. The surveyed line crosses Candle Creek about 1 mile above the mouth of Willow Creek. Candle Creek was nearly dry during 1907, the flow some of the time being less than half a second-foot.

Construction was begun late in 1907 by the Miners' Hydraulic Ditch Company on a second large ditch to Candle Creek. It will have its intake on Quartz Creek, a tributary of Kiwalik River from the east, and will extend along the right bank of that stream, crossing Hunter and Lava creeks by means of siphons and picking up their flow in lateral ditches. The ditch will have a length of about 60 miles and a bottom width of 12 feet.

A ditch was built in 1907 on Bear Creek, a tributary of West Fork of Buckland River. It has its intake below the mouth of May Creek and extends along the right bank to Split Creek, diverting Eagle, Polar, and other small creeks. The ditch has a length of about 6 miles, a bottom width of 6 feet, and a grade of 4 feet to the mile. The head obtained at the lower end is about 200 feet.

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RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All of these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained, free of charge (except certain maps), on application.
2. A certain number are delivered to Senators and Representatives in Congress for distribution.
3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost.
4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

GENERAL.

The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper No. 45, 1906, 327 pp.

Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin No. 259, 1905, pp. 18–31.

The mining industry in 1905, by A. H. Brooks. In Bulletin No. 284, 1906, pp. 4–9.

The mining industry in 1906, by A. H. Brooks. In Bulletin No. 314, 1907, pp. 19–39.

Railway routes, by A. H. Brooks. In Bulletin No. 284, 1906, pp. 10–17.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1904: Bulletin No. 259, 1905, pp. 13–17.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1905: Bulletin No. 284, 1906, pp. 1–3.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1906: Bulletin No. 314, 1907, pp. 11–18.

Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.

Markets for Alaska coal, by G. C. Martin. In Bulletin No. 284, 1906, pp. 18–29.

The Alaska coal fields, by G. C. Martin. In Bulletin No. 314, 1907, pp. 40–46.

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin No. 263, 1905, 362 pp. (Out of stock; can be purchased from Superintendent of Documents, Washington, D. C., for 35 cents.) Abstract in Bulletin No. 259, 1905, pp. 32–46.

Geographic dictionary of Alaska, by Marcus Baker, second edition by J. C. McCormick. Bulletin No. 299, 1906, 690 pp.

Administrative report, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1907. Bulletin No. 345, pp. 5–17.

The distribution of mineral resources in Alaska, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1907. Bulletin No. 345, pp. 18–29.

The mining industry in 1907, by A. H. Brooks. In Report on progress of investigations of mineral resources of Alaska in 1907. Bulletin 345, pp. 30–53.

Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin No. 345, 1908, pp. 54–77.

Water-supply investigations in Alaska in 1906–7, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, 159 pp.

Topographic maps.

Alaska, topographic map of; scale, 1:2500000. Preliminary edition by R. U. Goode. Contained in Professional Paper No. 45. Not published separately.

Map of Alaska showing distribution of mineral resources; scale, 1:5000000; by A. H. Brooks. Contained in Bulletin 345 (in pocket).

Map of Alaska; scale, 1:5000000; by Alfred H. Brooks.

In preparation.

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Second edition.

SOUTHEASTERN ALASKA.

Preliminary report on the Ketchikan mining district, Alaska, with an introductory sketch of the geology of southeastern Alaska, by Alfred H. Brooks. Professional Paper No. 1, 1902, 120 pp.

The Porcupine placer district, Alaska, by C. W. Wright. Bulletin No. 236, 1904, 35 pp.

The Treadwell ore deposits, by A. C. Spencer. In Bulletin No. 259, 1905, pp. 69–87.

Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin No. 259, 1905, pp. 47–68.

The Juneau gold belt, Alaska, by A. C. Spencer, pp. 1–137, and A reconnaissance of Admiralty Island, Alaska, by C. W. Wright, pp. 138–154. Bulletin No. 287, 1906, 161 pp.

Lode mining in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin No. 284, 1906, pp. 30–53.

Nonmetallic deposits of southeastern Alaska, by C. W. Wright. In Bulletin No. 284, 1906, pp. 54–60.

The Yakutat Bay region, by R. S. Tarr. In Bulletin No. 284, 1906, pp. 61–64.

Lode mining in southeastern Alaska, by C. W. Wright. In Bulletin No. 314, 1907, pp. 47–72.

Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. In Bulletin No. 314, 1907, pp. 73–81.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin No. 314, 1907, pp. 82–88.

Lode mining in southeastern Alaska in 1907, by C. W. Wright. In Bulletin No. 345, 1908, pp. 78–97.

The building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin No. 345, 1908, pp. 116–126.

Copper deposits on Kasaan Peninsula, Prince of Wales Island, by C. W. Wright and Sidney Paige. In Bulletin No. 345, 1908, pp. 98–115.

Topographic maps.

Juneau Special quadrangle; scale, 1:62500; by W. J. Peters. For sale at 5 cents each or $3 per hundred.

Topographic map of the Juneau gold belt, Alaska. Contained in Bulletin 287, Plate XXXVI, 1906. Not issued separately.

In preparation.

Physiography and glacial geology of the Yakutat Bay region, Alaska, by R. S. Tarr, with a chapter on the bed-rock geology by R. S. Tarr and B. S. Butler.

The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright.

Berners Bay Special map; scale, 1:62500; by R. B. Oliver. (In press.)

Kasaan Peninsula Special map; scale, 1:62500; by D. C. Witherspoon and J. W. Bagley.

CONTROLLER BAY PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

The mineral resources of the Mount Wrangell district, Alaska, by W. C. Mendenhall. Professional Paper No. 15, 1903, 71 pp. Contains general map of Prince William Sound and Copper River region; scale, 12 miles = 1 inch. (Out of stock; can be purchased from Superintendent of Documents for 30 cents.)

Bering River coal field, by G. C. Martin. In Bulletin No. 259, 1905, pp. 140–150.

Cape Yaktag placers, by G. C. Martin. In Bulletin No. 259, 1905, pp. 88–89.

Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139. Abstract from Bulletin No. 250.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.

Geology of the central Copper River region, Alaska, by W. C. Mendenhall. Professional Paper No. 41, 1905, 133 pp.

Copper and other mineral resources of Prince William Sound, by U. S. Grant. In Bulletin No. 284, 1906, pp. 78–87.

Distribution and character of the Bering River coal, by G. C. Martin. In Bulletin No. 284, 1906, pp. 65–76.

Petroleum at Controller Bay, by G. C. Martin. In Bulletin No. 314, 1907, pp. 89–103.
Geology and mineral resources of Controller Bay region, by G. C. Martin. Bulletin No. 335, 1908, 141 pp.
Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin No. 345, 1908, pp. 176–178.
Mineral resources of the Kotsina and Chitina valleys, Copper River region, by F. H. Moffit and A. G. Maddren. In Bulletin No. 345, 1908, pp. 127–175.

Topographic maps.

Map of Mount Wrangell; scale, 12 miles = 1 inch. Contained in Professional Paper No. 15. Not issued separately.
Copper and upper Chistochina rivers; scale, 1:250000; by T. G. Gerdine. Contained in Professional Paper No. 41. Not issued separately.
Copper, Nabesna, and Chisana rivers, headwaters of; scale, 1:250000. D. C. Witherspoon. Contained in Professional Paper No. 41. Not issued separately.
Controller Bay region Special map; scale, 1:62500; by E. G. Hamilton. For sale at 35 cents a copy or $21.00 per hundred.
General map of Alaska coast region from Yakutat Bay to Prince William Sound; scale, 1:1200000; compiled by G. C. Martin. Contained in Bulletin No. 335.

In preparation.

The Kotsina-Chitina copper region, by F. H. Moffit.
Chitina quadrangle map; scale, 1:250000; by T. G. Gerdine and D. C. Witherspoon.

COOK INLET AND SUSITNA REGION.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin No. 250, 1905, 64 pp.
Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin No. 259, 1905, pp. 151–171.
Gold placers of Turnagain Arm, Cook Inlet, by F. H. Moffit. In Bulletin No. 259, 1905, pp. 90–99.
Mineral resources of the Kenai Peninsula; Gold fields of the Turnagain Arm region, by F. H. Moffit, pp. 1–52; Coal fields of the Kachemak Bay region, by R. W. Stone, pp. 53–73. Bulletin No. 277, 1906, 80 pp.
Preliminary statement on the Matanuska coal field, by G. C. Martin. In Bulletin No. 284, 1906, pp. 88–100.
A reconnaissance of the Matanuska coal field, Alaska, in 1905, by G. C. Martin. Bulletin No. 289, 1906, 36 pp. (Out of stock; can be purchased of Superintendent of Documents for 25 cents.)
Reconnaissance in the Matanuska and Talkeetna basins, by S. Paige and A. Knopf. In Bulletin No. 314, 1907, pp. 104–125.
Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska, by S. Paige and A. Knopf. Bulletin No. 327, 1907, 71 pp.

Topographic maps.

Kenai Peninsula, northern portion; scale, 1:250000; by E. G. Hamilton. Contained in Bulletin No. 277. Not published separately.
Reconnaissance map of Matanuska and Talkeetna region; scale, 1:250000; by T. G. Gerdine and R. H. Sargent. Contained in Bulletin No. 327. Not published separately.
Mount McKinley region; scale, 1:625000; by D. L. Reaburn. Contained in Professional Paper No. 45. Not published separately.

ALASKA PENINSULA AND ALEUTIAN ISLANDS.

Gold mine on Unalaska Island, by A. J. Collier. In Bulletin No. 259, 1905, pp. 102–103.
Gold deposits of the Shumagin Islands, by G. C. Martin. In Bulletin No. 259, 1905, pp. 100–101.
Notes on the petroleum fields of Alaska, by G. C. Martin. In Bulletin No. 259, 1905, pp. 128–139. Abstract from Bulletin No. 250.
The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. In Bulletin No. 250, 1905, 64 pp.
Coal resources of southwestern Alaska, by R. W. Stone. In Bulletin No. 259, 1905, pp. 151–171.
The Herendeen Bay coal field, by Sidney Paige. In Bulletin No. 284, 1906, pp. 101–108.

YUKON BASIN.

The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin No. 218, 1903, 71 pp.
The gold placers of the Fortymile, Birch Creek, and Fairbanks regions, by L. M. Prindle. Bulletin No. 251, 1905, 89 pp.
Yukon placer fields, by L. M. Prindle. In Bulletin No. 284, 1906, pp. 109–131.
Reconnaissance from Circle to Fort Hamlin, by R. W. Stone. In Bulletin No. 284, 1906, pp. 128–131.
The Yukon-Tanana region, Alaska; description of the Circle quadrangle, by L. M. Prindle. Bulletin No. 295, 1906, 27 pp.
The Bonnifield and Kantishna regions, by L. M. Prindle. In Bulletin No. 314, 1907, pp. 205–226.
The Circle Precinct, Alaska, by Alfred H. Brooks. In Bulletin No. 314, 1907, pp. 187–204.
The Yukon-Tanana region, Alaska; description of the Fairbanks and Rampart quadrangles, by L. M. Prindle, F. L. Hess, and C. C. Covert. Bulletin No. 337, 1908, 102 pp.
Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin No. 345, 1908, pp. 179–186.
The Fortymile gold placer district, by L. M. Prindle. In Bulletin No. 345, 1908, pp. 187–197.
Water supply of the Fairbanks district in 1907, by C. C. Covert. In Bulletin No. 345, 1908, pp. 198–205.

Topographic maps.

Fortymile quadrangle; scale, 1:250000; by E. C. Barnard. For sale at 5 cents a copy or $3 per hundred.
Yukon-Tanana region, reconnaissance map of; scale, 1:625000; by T. G. Gerdine. Contained in Bulletin No. 251, 1905. Not published separately.
Fairbanks and Birch Creek districts, reconnaissance maps of; scale, 1:250000; by T. G. Gerdine. Contained in Bulletin No. 251, 1905. Not issued separately.
Circle quadrangle, Yukon-Tanana region; scale, 1:250000; by D. C. Witherspoon. Contained in Bulletin No. 295. Not issued separately.

In preparation.

Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, 159 pp.
Fairbanks quadrangle map; scale, 1:250000; by D. C. Witherspoon. Contained in Bulletin No. 337, 1908.
Rampart quadrangle map; scale, 1:250000; by D. C. Witherspoon. Contained in Bulletin No. 337, 1908.
Fairbanks Special map; scale, 1:62500; by T. G. Gerdine and R. H. Sargent.

SEWARD PENINSULA.

A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska, in 1900, by A. H. Brooks, G. B. Richardson, and A. J. Collier. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900," 1901, 180 pp.
A reconnaissance in the Norton Bay region, Alaska, in 1900, by W. C. Mendenhall. In a special publication entitled "Reconnaissances in the Cape Nome and Norton Bay regions, Alaska, in 1900."
A reconnaissance of the northwestern portion of Seward Peninsula, Alaska, by A. J. Collier. Professional Paper No. 2, 1902, 70 pp.
The tin deposits of the York region, Alaska, by A. J. Collier. Bulletin No. 229, 1904, 61 pp.
Recent developments of Alaskan tin deposits, by A. J. Collier. In Bulletin No. 259, 1905, pp. 120–127.
The Fairhaven gold placers of Seward Peninsula, by F. H. Moffit. Bulletin No. 247, 1905, 85 pp.
The York tin region, by F. L. Hess. In Bulletin No. 284, 1906, pp. 145–157.
Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin No. 284, 1906, pp. 132–141.
The Kougarok region, by A. H. Brooks. In Bulletin No. 314, 1907, pp. 164–181.

Water supply of Nome region, Seward Peninsula, Alaska, 1906, by J. C. Hoyt and F. F. Henshaw. Water-Supply Paper No. 196, 1907, 52 pp. (Out of stock; can be purchased of Superintendent of Documents for 15 cents.)
Water supply of the Nome region, Seward Peninsula, 1906, by J. C. Hoyt and F. F. Henshaw. In Bulletin No. 314, 1907, pp. 182–186.
The Nome region, by F. H. Moffit. In Bulletin No. 314, 1907, pp. 126–145.
Gold fields of the Solomon and Niukluk river basins, by P. S. Smith. In Bulletin No. 314, 1907, pp. 146–156.
Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin No. 314, 1907, pp. 157–163.
The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin No. 328, 1908, 343 pp.
Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin No. 345, 1908, pp. 206–250.
The Seward Peninsula tin deposits, by Adolph Knopf. In Bulletin No. 345, 1908, pp. 251–267.
Mineral deposits of the Lost River and Brooks Mountain regions, Seward Peninsula, by Adolph Knopf. In Bulletin No. 345, 1908, pp. 268–271.
Water supply of the Nome and Kougarok regions, Seward Peninsula, in 1906–7, by F. F. Henshaw. In Bulletin No. 345, 1908, pp. 272–285.

Topographic maps.

The following maps are for sale at *5 cents a copy*, or $3 per hundred:
Casadepaga Quadrangle, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.
Grand Central Special, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.
Nome Special, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.
Solomon Quadrangle, Seward Peninsula; scale, 1:62500; by T. G. Gerdine.

The following maps are for sale at *25 cents a copy*, or $15 per hundred:
Seward Peninsula, northeastern portion of, topographic reconnaissance of; scale, 1:250000; by T. G. Gerdine.
Seward Peninsula, northwestern portion of, topographic reconnaissance of; scale, 1:250000; by T. G. Gerdine.
Seward Peninsula, southern portion of, topographic reconnaissance of; scale, 1:250000; by T. G. Gerdine.

In preparation.

Water-supply investigations in Alaska, 1906 and 1907, by F. F. Henshaw and C. C. Covert. Water-Supply Paper No. 218, 1908, 159 pp.
Geology of the area represented on the Nome and Grand Central Special maps, by F. H. Moffit, F. L. Hess, and P. S. Smith.
Geology of the area represented on the Solomon and Casadepaga Special maps, by P. S. Smith.
The Seward Peninsula tin deposits, by A. Knopf.

NORTHERN ALASKA.

A reconnaissance from Fort Hamlin to Kotzebue Sound, Alaska, by way of Dall, Kanuti, Allen, and Kowak rivers, by W. C. Mendenhall. Professional Paper No. 10, 1902, 68 pp.
A reconnaissance in northern Alaska across the Rocky Mountains, along the Koyukuk, John, Anaktuvuk, and Colville rivers, and the Arctic coast to Cape Lisburne, in 1901, by F. C. Schrader and W. J. Peters. Professional Paper No. 20, 1904, 139 pp. (Out of stock; can be purchased of Superintendent of Documents for 40 cents.)
Coal fields of the Cape Lisburne region, by A. J. Collier. In Bulletin No. 259, 1905, pp. 172–185.
Geology and coal resources of Cape Lisburne region, Alaska, by A. J. Collier. Bulletin No. 278, 1906, 54 pp.

Topographic maps.

Fort Yukon to Kotzebue Sound, reconnaissance map of; scale, 1:1200000; by D. L. Reaburn. Contained in Professional Paper No. 10. Not published separately.
Koyukuk River to mouth of Colville River, including John River; scale, 1:1200000; by W. J. Peters. Contained in Professional Paper No. 20. (Out of stock.) Not published separately.

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